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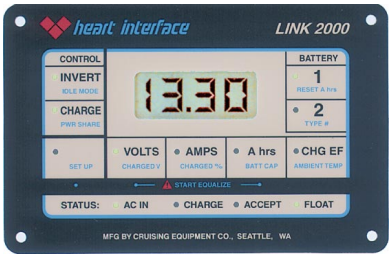

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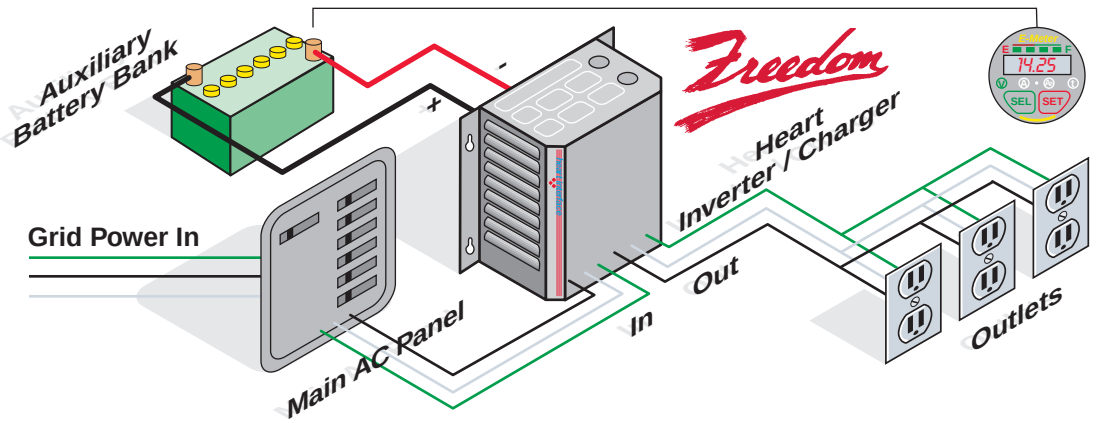

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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #52 April / May 1996

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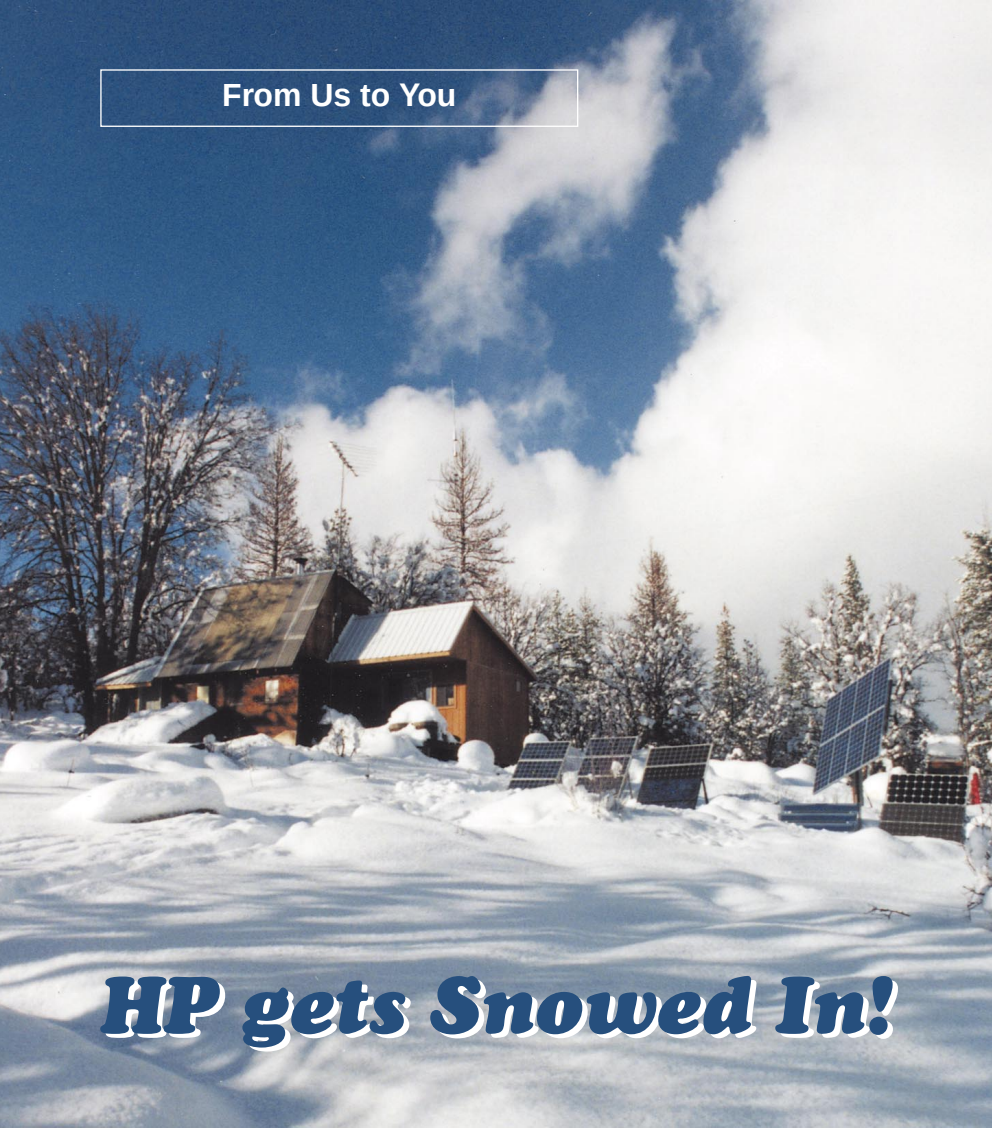

HP gets Snowed In!

The Winter of 1996 was a toughie here at Home Power Central on Agate Flat. For weeks on end it seemed the snow never stopped. At one point we measured the snow depth, in the open, at 49.1 inches. We were paralyzed. We had our truck stuck in a snowbank about 1.5 miles from our home and office. We backpacked in all of our supplies through waist deep snow. As I write this (3 March), we have still to get the truck to HP Central on a regular basis. I wait for a frozen morning and hope to zip in without getting big time stuck. And big time stuck we have been twice this winter. Many thanks to our good neighbor, Jim Murdock, who towed us out with his bulldozer.

HP Crew Members Ben Root (left) and Michael Welch (right) get ready to pack to the stuck truck.

While transportation ground to a halt and power failed everywhere around us, our RE systems trucked on through the snow. We had to shovel out the PV arrays every morning, but they still made solar electricity for us. Our wind generator still produced power in spite of the deep snow. We rediscovered the joys of being snowed in and wanted to share them in the form of these pictures.

Richard Perez for the Home Power Crew

People

Dale Andreatta
Sam Coleman
John Dailey
William Farrell
Roger Gastrow
Steven Gima
Michael Hackleman
Mike Islam
Kathleen Jarschke-Schultze
Jon Kenneke
Stan Krute
Don Loweburg
Harry Martin
Karen Perez
Richard Perez
Shari Prange
Eileen Puttre
Benjamin Root
Hugh Spencer
Bob-O Schultze
Larry Warnberg
Michael Welch
John Wiles
Myna Wilson

" Think about it..."

"If you want to make an apple pie from scratch, you must first create the universe."

Carl Sagan

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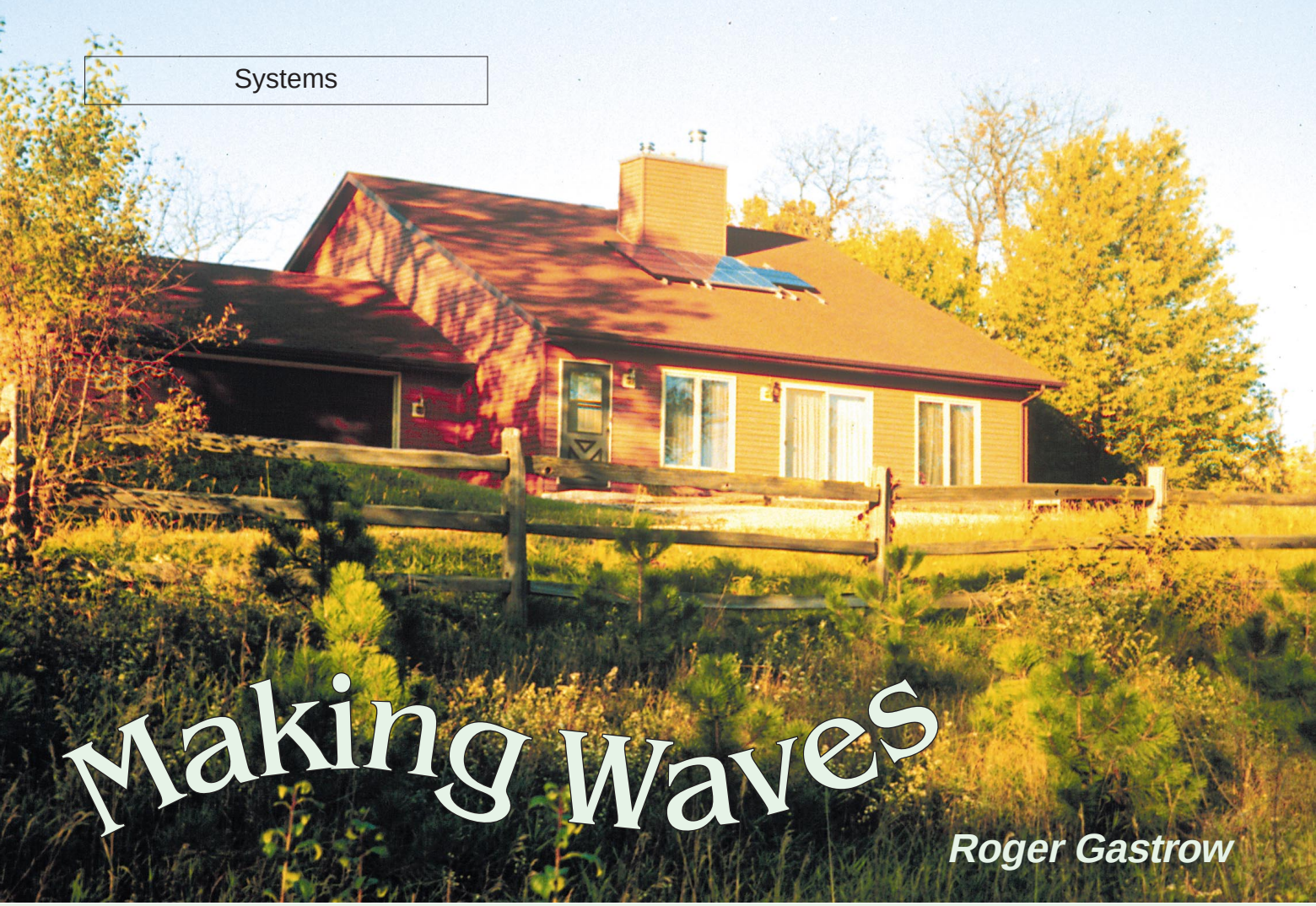


Making Waves

Roger Gastrow

I think it started when I was six. My electric toy cars just kept running out of battery power. After much thought, I borrowed some paper clips, an empty wooden sewing spool and some scotch tape and proceeded to construct a solar battery charger. Needless to say it didn't work, but it was a start. I never thought that just over 25 years later, most of my home would be powered by sunshine.

So...Welcome to Wisconsin

We live in the "Kettle Moraine" area near a small town named North Prairie, about 45 minutes southwest of Milwaukee. Here, occasionally you'll see a wind generator, some houses with solar hot water heating, but no homes with PV power. Everyone here is within arms reach of the power grid, so why bother? I really don't know why, But I think its probably the same reason that people climb mountains—for me the technical challenge.

I first learned about *Home Power Magazine* from an ad in *Back Home Magazine*. It was exciting for me because after researching renewable energy for years, the libraries only had old materials that were sadly out of date. I quickly called and Karen sent me a free issue—after which I promptly subscribed.

Well, you gotta start somewhere!

After telling my wife Monica about my idea (and months of convincing), we started with reducing electrical loads. Monica actually started our energy savings by finding a rebate program from Wisconsin Electric. They would rebate us $10 for every fluorescent energy efficient lamp we purchased—up to 12 of them. I couldn't believe it when the electric company sent us a check for $120.00! Wisconsin Electric frequently has different programs to encourage energy conservation. I really had to twist their arm to get a rebate on my Sun Frost, though—they had never heard of it. Which brings us to our next step.

Our refrigerator was in need of replacement, so after examining all the alternatives, we decided to save for a Sun Frost. Our model is a white RF-16, powered by 120

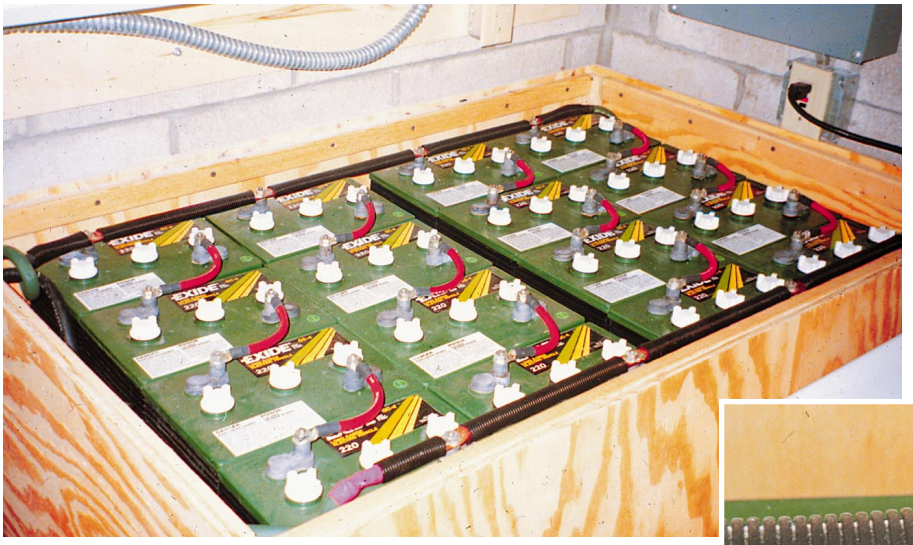
vac. Who ever said energy conservation meant going without! It does some tricks our old refrigerator didn't do, such as holding two one-liter soda bottles on the door and it offers total control of freezer and refrigerator temperatures. It wasn't cheap, but then good stuff usually isn't. The beauty of the Sun Frost is its simple logical layout, heavy insulation, compressors on top, glass shelves and plenty of room for everything. The company is also very good to deal with. They've always answered any questions I've had.

Believe it or not,up till this point, I'd never seen a working solar panel. So before covering the roof with them, Monica suggested we take a look at some. After some looking, we linked up with Chris Brile from Photocomm in Downers Grove, Illinois. He really was a valuable find and taught us the basics of solar. It was refreshing when we asked questions and got good answers, whether it made him a sale or not. Sadly, several months after our meeting , he was killed in an auto accident along with his son. I still carry his business card in memory.

By this time, we had our first eight panels—Kyocera K51s. After designing a rack and obtaining some aluminum, we hoisted them onto the roof—all eight at once. What a job! The panels are connected with water tight flexible conduit with low oxygen wire and are

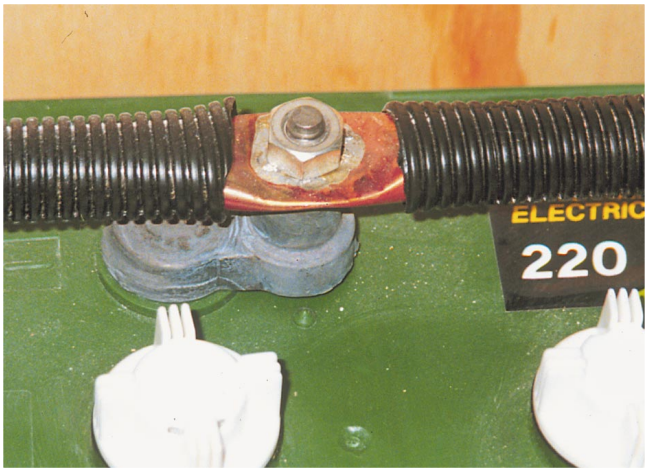
Above: Monica shows off the Sunfrost RF-16.

Below: Roger on the roof adding Solarex MSX-60 panels to the existing array of Kyocera K-51's.



Left: Sixteen of the twenty-eight Exide GC-4 batteries. 1540 Ampere-hours at 24 Volts DC.

Below: A close up of the copper bus bar showing the wire loom covering and tinned area for better contact.



grounded at the junction box on the roof. Four runs of #4 wire run from the roof into the basement in 1 1/4 inch PVC conduit, along with the ground. Always figure on expansion. According to my calculations, this wiring should be good for about 2400 Watts of solar. Some good tips here are: 1) solder all connections, 2) use spade lug connectors when wiring panels, 3) use heat shrink tubing liberally after cleaning rosin and other stuff off the wires, and 4) a weatherproof terminal block on the roof makes it much easier to expand your system.

Originally, our system was designed for two inverters, an “always on” switch mode type and a “brute force” transformer type for heavy loads such as water pumping. Logically then, our next acquisition was a PowerStar 1500 watt inverter. I still can’t believe that a box the size of a block of Velveeta cheese could power our Kenmore washer, refrigerator, freezer, TV and lights, all at the same time! After researching batteries we decided to try alkaline batteries; the idea of batteries going after ten years didn’t appeal to me. After saving again, we purchased a set of batteries—supposedly new, sight unseen. Big mistake! Upon arriving, they were battered, minus electrolyte, one cell was different from the others and a majority “rattled.” In the bottoms of the cells, that nasty black ookie graphite had leaked from the plates. Of course, I was reassured that these were new and I should give them a chance. After receiving the chemicals, I mixed the electrolyte and charged the cells. So far, this had taken four months to receive all the parts for the batteries.

After charging and charging and charging, I was ready for the capacity test. Armed with my Cruising Amp Hour +2 and Fluke 87 meter I watched and measured. Results? 42 AH out of a 320 AH battery. Subsequent tests only got worse. The cells came with a “no questions asked” return policy which I now decided to exercise. The dealer informed me he would not return my money! After the threat of legal action and several months, I did receive some merchandise to make up for most of the difference.

At this point I got some good advice from the dealers I do business with now. Some good guidelines for selecting an RE (renewable energy) dealer are:

1 Deal with a local dealer if possible. It’s always easier to solve problems and ask questions of someone nearby and familiar with your situation.

2 Ask to see systems they have installed and work they have done. Don’t be satisfied with “Rube Goldberg” looking jobs—remember, even though you are dealing with renewable energy, this is high power stuff and installed incorrectly, it can be dangerous.

3 Do they live with what they sell? Would you buy a car from someone who never drove one? Of course not! Dealers that live with the items they sell are more likely to know what to expect and any quirks the items may have.

4 Shop for a good deal, but don’t beat them up for pricing. If something is being sold for a lower than

normal price—beware. You may not get any backup on questions or problems you may have. Even in this business, there are quick-buck "fly by night" dealers. If it's too good to be true in price or performance, it probably is.

5 Be realistic in your expectations—especially in what you expect to use and produce. When seasons charge, a little foresight will keep you from being caught short. Remember not to waste the time of the dealer if you honestly have no intention of buying anything. They need to make a living too.

6 See what you are buying. Even if it means taking a trip to see it, it may save a lot of disappointment later. Some things, such as panels are pretty universal, so once you've seen one you know what to expect; but meters, batteries, pumps, and other specialized equipment deserves more attention.

And now … back to the system

After the battery problem, a friend set me on the trail of some brand new Exide GC-4 batteries available locally. Best of all, I got all 28 of them by bartering for them! What can I say? With 1540 Ampere-hours at 24 VDC, I now have more than enough power for dismal weather, short sun days in winter, and high surges. Lead acid isn't so bad, just study up on their characteristics and treat them nicely. The buss bars in the back were made by strategically crimping a piece of copper water pipe, drilling holes in the correct places, then tinning the exposed areas with solder to prevent corrosion. The ends connect directly to 3/0 UL approved cable. In the battery bank as on the roof, solder all connections and use heat shrink tubing (correctly color coded) on all interconnects. Wire loom used in car stereo installations fits neatly over the copper pipe and prevents accidents if you drop your screwdriver in there.

In the controls department, we use a Trace C-30A charge controller. Nothing fancy yet, but it works nicely. As the system grows, I'll be installing a home brew diversion regulator to regain some of those lost electrons on long summer days. For metering, we have a Cruising Amp Hour +2 meter. One channel measures daily power production and the other measures battery charge capacity. It's a nice meter but has a few things that could use improving. First, the charge channel resets itself when the batteries stop charging—so you have to race to the control panel before the sun sets to find out how much power you produced that day. The other bummer is the battery charge efficiency function. According to what I've read, the battery needs to be cycled from full charge to over 30% discharge several times for the calculation to be made. That's fine but we've never used more than 25% of our battery storage. I'm sure by now Cruising has addressed the problem and I still think it's a good basic meter. It is also pretty accurate on voltage and current measurements.

At this time we added six Solarex MSX60 PV panels to the system. This brings up that burning question in any person's mind that is thinking about panels—which work best? From our experience, both are great panels and I wasn't disappointed by either's performance. The Kyocera panels are a little cheaper per Watt, but Solarex has a 20 year warranty and nice heavy black anodized aluminum. Their junction boxes are also a little roomier for heavy wiring. The only tip I can relate here is make sure that your panels are of compatible voltages when mixing panel types.

Solarocity achieved

After operating our system with the PowerStar inverter for over a year, we decided to proceed with the next step—the water pump. It took months of study; reading, hair pulling, and "sleeping on it" to make a decision on how to do this. In our area, we don't have a local dealer that distributes the nice low voltage pumps that some RE systems have, and after the alkaline battery thing, I decided to use local technology. About the time I thought I knew what to do, the new Trace sine wave came out. After talking to as many people as I could find, I went for it. It wasn't easy, it is expensive, but wow! What an inverter! Even with all its great options, we use it for its primary purpose, a stand alone sine wave inverter. After rewiring, adding some more conduit

Above: Roger and Monica enjoying the comfort of their renewable-powered home.

Above: The battery box and control center including a Trace SW-4024, C-30A, and Cruising AH+2 meter.

and a new refurbished breaker, we were ready. The well pump was a 220 vac, two wire, Jacuzzi pump with pressure switch in the basement. We added the Trace T-220 autotransformer to run the pump.

Time for the big test. First the countdown ... 5–4–3–2–1 hit it! ... Nothing—except the 260 Amps discharge reading on my Cruising meter! The rotor in the pump's motor locked and wouldn't run. Even with this huge surge, the lighting stayed on and no inverter noise was heard. We tested the pump and found that with this arrangement it would start about 80% of the time. In retrospect, here's what probably happened. Two-wire pumps have a large capacitor in the motor to create a phase shift to start the motor. While the SW4024 is more than capable of starting a 1/2 horse pump, it seems the autotransformer inductance was cancelling out the inverter's power factor correction to start it, so there was no phase shift in the pump to start it.

When wiring for water pumping, here are some shortcuts to save time and money:

1 Read all the articles that Windy Dankoff has written in *Home Power* about ac pumping.

2 Do not use a two-wire pump, especially with an autotransformer. Some may work but some may not.

3 Make sure you have a large pressure tank so the pump doesn't continually cycle.

4 Even with a sine wave inverter, use the relay type starter box on three-wire pumps instead of the solid state version. The solid state box is much more susceptible to lightning damage (ground strikes) and won't work with modified sine wave inverters at all.

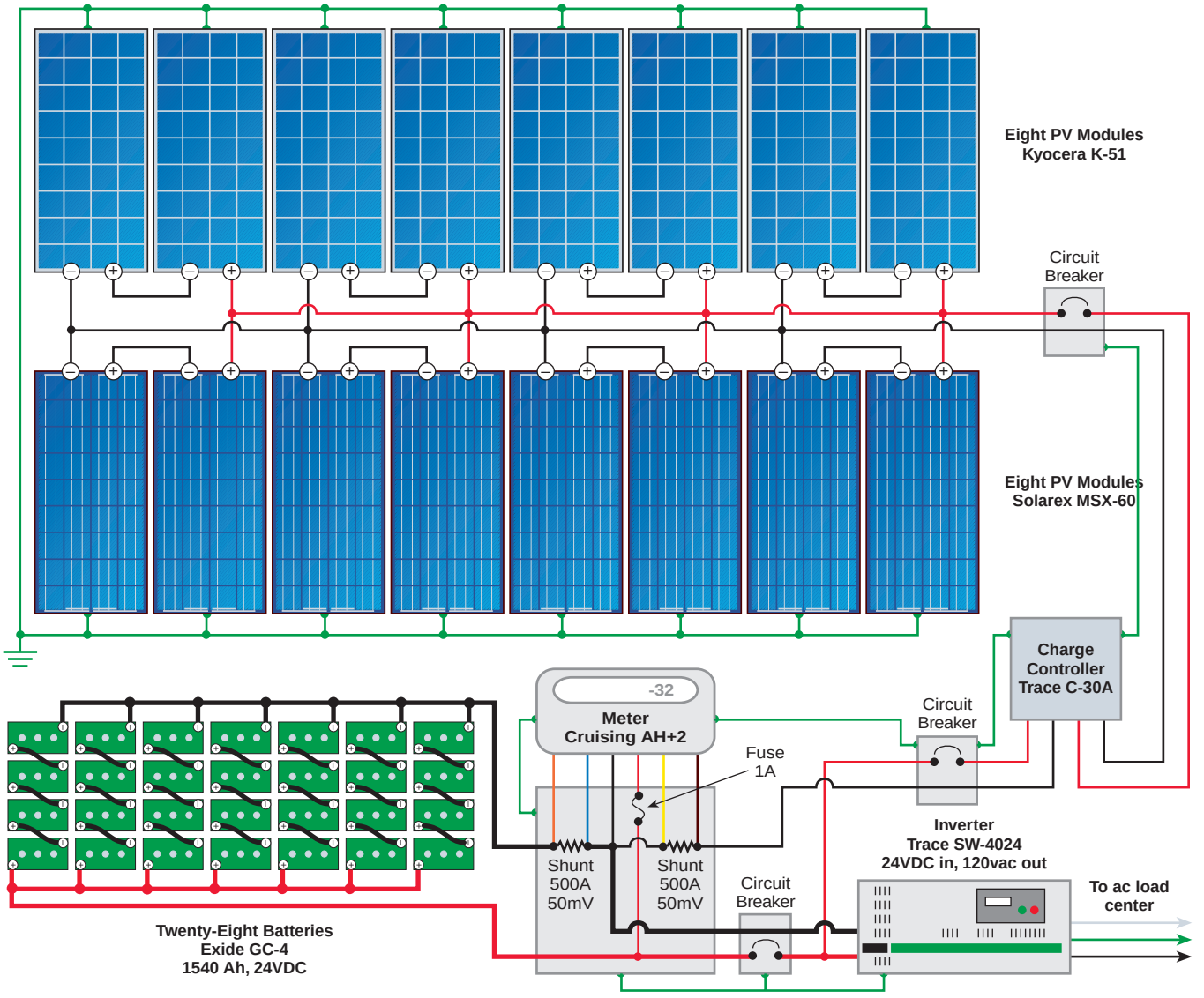
Finally, we decided to do this right. We replaced the pump and wiring. Our new pump is a Red Jacket 1/2 horse, three-wire, 120 vac pump with the relay type starter. It took some convincing of the pump man to put this in, because it isn't a "stock" pump. It works beautifully, charging our pressure tank in about 75 seconds up to 60 pounds of pressure. The inverter doesn't even flinch when starting it, even when it's running the washer and the rest of the house!

Electrons in action

In our system, we started with power conservation, then fitted the system to what it would power. Primary concerns were refrigeration and water pumping. Most 120 vac equipment works fine on sine wave power, but we did fine tune some things to work better. A regular refrigerator would draw too much power, so we were especially curious to see how well the Sun Frost lived up to its claims. After about six months of daily measurement, we found it consumes about 900–1000 watt hours per day. When you figure inverter inefficiency into the picture, this really isn't too bad. The water pump, when running, draws about 1400 watts and surges at about twice that when starting. When figuring the number of cycles and duration of the pumping time, it uses about 350 watt hours per day.

Figuring the wash load is a little more difficult. The stock Kenmore washer we have is about ten years old and washes an average load for about 400 watt-hours. When we ran the washer on the PowerStar inverter, we used a large isolation transformer to prevent problems with the directly coupled semiconductors in the output section.

In the entertainment department we have an NEC 26" TV, slightly modified. When running, it now consumes less than 100 watts. Things to look for in an efficient TV are a switch mode power supply and battery backup of any memory the TV stores. This is important since almost all TVs are phantom loads—consuming power even when they are not on. We mounted a power strip with switch next to ours to shut off the TV and VCR. Our



VCRs each use about 15 watts when on. One is an NEC model 959, the other a JVC, which after modifying, remembers the time and programming for about a month without being plugged in. Ever wonder how much power your VCR consumes just sitting there with the time on and the switch off? The average is about 4 watts. Quite a phantom load! In the stereo department, we use a modified JVC RX-2 receiver. The power transformer was moved to the secondary side of the power switch to eliminate its power consumption when turned off. When using a stereo on an RE system, check its idle current rating. Some amplifiers come set from the factory to draw an excessive amount of power to bias the output transistors. Have a competent technician set yours up for its optimum operating point. The CD player is a stock Luxman DZ-111, drawing about 11 watts when running. For cassette tapes we use an unmodified Pioneer deck.

Lighting is provided by a combination of Osram and Lights of America fluorescent lamps of various sizes. One thing to make note of—any switch mode type fluorescent will wake the Trace inverter out of sleep mode—even a 7 watt will, but no combination of the magnetic type ballast lamps will wake the inverter. Magnetic ballast type lamps do not have a surge high enough initially to trick the inverter into the on mode. If you use magnetic type ballast lamps, use a switch mode type also to bring the inverter into on mode.

Kudos where they're due

Along the way we've had some good help and encouragement from dealers I'd like to share with you. Gunars Petersons from Alternative Light and Power has been an invaluable help on the controls and high power part of our system. Even though his store is over four hours away, it's nice to drive out and see what's new. I've also gotten good assistance from Mick Abraham

from Abraham Solar in Colorado. Mick once sent a letter of encouragement when we were having some problems with our system during the “nickel iron” experiment, and I keep that letter handy to re-read when the chips are down. Thanks also go to Karen and Richard at *Home Power* for information and several lengthy phone conversations worth of education. No project like this ever happens without the support of family and friends. I’m glad Monica, my wife, and Ralph Diehl, my friend and fellow mad scientist, were both there to help.

So what’s next?
A home brew efficient freezer might be a future project. Hydrogen?—maybe. Wind power? I don’t know. More panels? Definitely. When friends stop by, the first question of course is “So how’s it work?”. The answer: “Well, the sun shines on the panels and the electrons get excited” …but what they really want to know is how well does it work. It’s simply wonderful. However, the really amazing part is done by the God we believe in that makes the sun shine on all of us.

Access
Roger Gastrow, c/o *Home Power*, PO Box 520, Ashland, OR 97520

ANANDA POWER TECHNOLOGIES

four color on film negatives

full page

This is page 13

Hydro Power DONE DIRT CHEAP

Stephen M. Gima & Eileen Puttre

Eileen and I are both firm believers in the information super highway. She uses it (via the Internet) and I build it, being employed by a telecommunications company. Maybe it was ironic when we started looking for a home in the Adirondacks, we fell in love with the one a mile off the grid.

Above: Steven Gima performing the final assembly of his $328 hydro system.

It's a log cabin, built by a local mason, on an abandoned logging road. I guess after the initial construction in 1980, he kinda lost interest. When we found it, it looked like it was hardly ever used. The center hall fireplace and stove could not have burned more than a 1/4 cord of wood.

While the house had a kitchen and bathroom, the water fixtures only got water in the spring, due to the rise in the creek behind the house. There were also no lights except for the camping lantern we used to bring up. About the only thing that did work with any regularity was the propane oven.

Since light was our first consideration, we discovered by thumbing through non-electric catalogues that "Humphry" made wall mounted gas lights. So with 100 feet or so of 3/8 inch copper tubing, the main living quarters, downstairs, now had lights.

Well, about this time Eileen got a corporate level job with a photovoltaic company. We were thrilled! Maybe we could actually produce our own electricity. Our euphoria didn't last. Even at cost, photovoltaic panels were pretty expensive and for that part of the country especially, since it seems the sun hardly ever shines. Upon further investigation, it seems we get the least amount of available sunshine in the lower 48 states.

By now we were learning a little about renewable energy. The creek turned out to be a gold mine. Searching through and throughly reading everything we could find on the subject, we became convinced that a micro-hydroelectric system was the way to go. But still, a Harris Hydroelectric Generator, at about $1,000 was still a little more than we could afford.

A friend of ours in the Adirondack area, who happens to be an electrician, thought we might try to build a hydroelectric generator ourselves. Our friend located an "American Bosch" 12 VDC permanent magnet generator through a surplus catalogue.

The phone company, where I work, was trying to unload 6,000 feet of reeled 1 1/2 inch semi rigid conduit used for buried fiber optic applications. Over the next few months I managed to get about 1,000 feet of it in roughly 200 foot coils. Try coiling 200 feet of 1 1/2 inch semi-rigid conduit, then hauling it in a Toyota pickup 200 miles. It's a wonder that we never got stopped by

Above: Three pieces of 1.5 inch conduit emerge from the 6 inch diameter, 6 foot long PVC through pipe in the rock dam. The water level above the dam averages 3 feet.

the police, maybe they just shook their heads and laughed. But we never had any trouble. As hard as it was coiling the conduit, uncoiling it is even worse.

We ran the first piece from a dam we rebuilt (twice) in back of the house, along the creek bed and down, an overall drop of about 35 feet, to what looked like a suitable spot to secure our little hydro setup. With stop watch and buckets in hand, we determined the flow through the conduit to be about 35 gpm. Over the course of the next several weeks, we ran a total of three 1 1/2 inch permanently lubricated semi-rigid conduits, each 265 feet long. We placed ball valves half the distance from the dam to the generator.

The dam's been rebuilt (the mason who built the house constructed the original dam) placing a 6 foot length of 6 inch PVC on the bottom, then grading on an incline with rocks. It has only washed out once since then, but we've learned a lot about dam building. The three conduits were drilled and screened with 30 opposing 1/2 inch holes along the length at the dam then pushed through the 6 inch PVC and secured.

The creek flows from behind the house to around the side about 100 feet from the house. The hydro system, about 150 feet from the front of the house, was set-up on a rock stand next to the creek and secured in place with cement. The three 1 1/2 inch in conduit pipes were glued to 2 inch sweeps aimed at a pelton wheel and reduced to 5/16 inch nozzles.

All this took an entire summer of weekends. By mid-October we were ready to test. Without even owning a multimeter at the time, we took an old automotive headlight wired directly to the generator, turned on the valves and surprise, surprise, it lit. I doubt Thomas Edison was as happy as Eileen and I. We happily danced and congratulated ourselves for hours. By that evening we had run two #6 AWG wires up to the rear of the house and hooked up our headlight direct. The entire back area of the house lit up. From then until mid-December, when snow makes it impossible to get to the house by car, we would go up for weekends, open the valves and turn on our light.

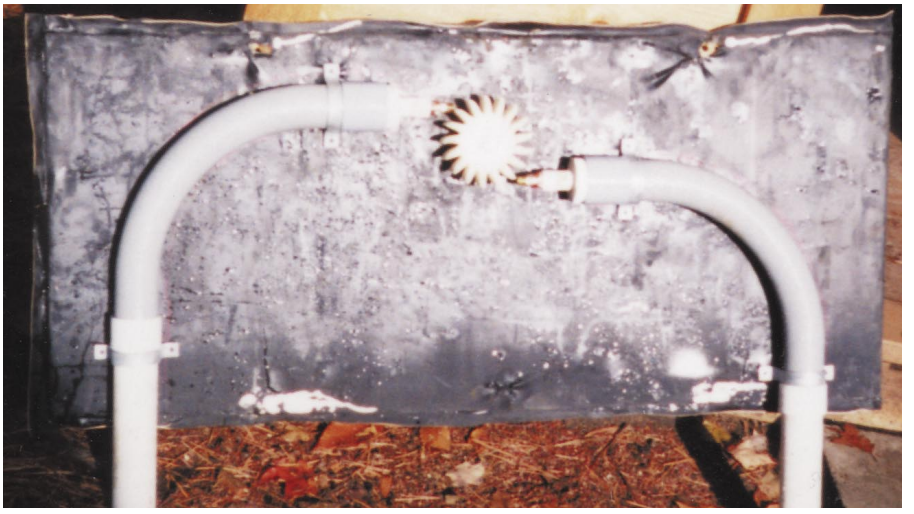
So far we had spent about $80. The generator was only $13, And the ball valves were about $20 each. I made the nozzles from a box of

Below: A view of Steven and Eileen's log cabin in the Adirondacks. The creek supplies them with power for their weekend retreats.

spare plumbing parts. The 6 inch conduit I found. The 800 feet of conduit, the PVC sweeps, and the squared and hollowed tub for the hydro plus all the wire (considered scrap) was courtesy of “Ma Bell”.

Our electrician friend had mountains of old electrical switches, fuses, and boxes. We told him what we thought we might need, which he gave to us. We went home for the winter and started to clean and separate everything.

When we started all of this, I knew virtually nothing about DC electricity, but by spring we had put together our pull-out fused disconnect with two 60 amp cartridge fuses, and our fused DC load center pieced together from several old glass buss fuses and holders. My son, Jesse, had a five year old battery in his car so he got a new battery and we got his old one. Don’t laugh, it worked. So that spring we were ready to make our system as safe as we knew how and bring electric lighting indoors.



Above: A close-up view of the pelton wheel (5 inches in diameter) and the two 2 inch sweeps that end in improvised 5/16 inch nozzles.

Below: The completed hydro plant showing the two diverters used when the cabin is unoccupied.

We cut out a spot under the living room steps for access to the crawl space below the house. Luckily we chose that particular spot. We had about 2 feet from the floor joists to the dirt below. The rest of the crawl space wasn’t so spacious, but being somewhat thin, I managed to fit.

Having access to an unlimited supply of 6 gauge wire, we bonded two pieces twice for positive and negative. This is roughly the equivalent of 3 gauge wire. It is well within line loss limits for the 150 feet from the hydro system to the house. The charge controller, main disconnect, and DC outlet center are all set-up under the steps. The batteries are directly under the steps in the vented crawl space next to the access door.

The automotive battery plus two 12 VDC Hawker Energy HD30 batteries worked well all summer. For the winter, the batteries remain home in New Jersey along with our dump truck and bulldozer batteries. All are kept in the garage on solar chargers. We’ll probably get two 6 VDC golf cart batteries for next spring, but we were pleasantly surprised that the old car battery performed so well.

So far we’ve only been able to get the hydro to put out 1.75 Amps, but

Stephen & Eileen's Hydro System Cost

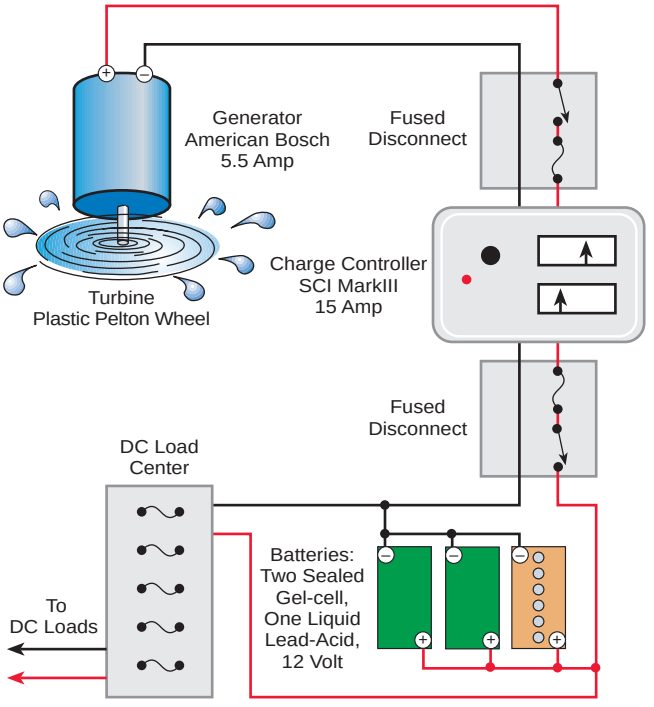
Item	*Cost*	*%*
Plastic Pelton Wheel	$75	23%
5.5 Amp, 12 VDC, PM Generator	$13	4%
SCI Mk III Regulator, w/Meters	$110	34%
Three Ball Valves	$60	18%
Battery Safety Switch	$20	6%
Lugs, Fuses & Hardware	$50	15%
Total Cost	$328	

Everthing else for the hydro system was either found or donated

it's enough to keep the batteries charged. We shut down the system during the week while we're not there and turn it on Friday night until Sunday morning.

What started as a headlight burning in the back has grown to be lighting for a tool shed, wood shed, front porch, bathroom, and, soon, upstairs bedroom. The downstairs is still using gas lights and they're great, each producing the equivalent of 50 watts of light.

But the biggest benefit is the electric water pump. We pump water from the creek to the tool shed where the pump and propane water heater are located. From there, it is another 60 feet to the house. Finally, last summer and fall we had indoor hot water showers. Until then, we used a solar shower on the front porch, which is fine in July but a little tough around October and November. Good thing we're a mile from our



Above: Steven installs the gravity feed water system which is filled by the hydro-electric powered pump.

nearest full time neighbor. We've only had a few close calls while showering on the porch. Luckily you can hear approaching visitors before they see the house.

Since we only use the house on weekends and a few weeks during the summer months, all the appliances are 12 Volt DC models. We thought of adding a small inverter but we get along just fine for now.

Acquiring the knowledge and resources for our place in the woods was an enjoyable learning experience and one we hope to duplicate when it comes time to build our permanent home in the Adirondacks.

Access

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Pelton Wheel: Alternative Energy Engineering, PO Box 339, Redway, CA 95560 • 800-777-6609

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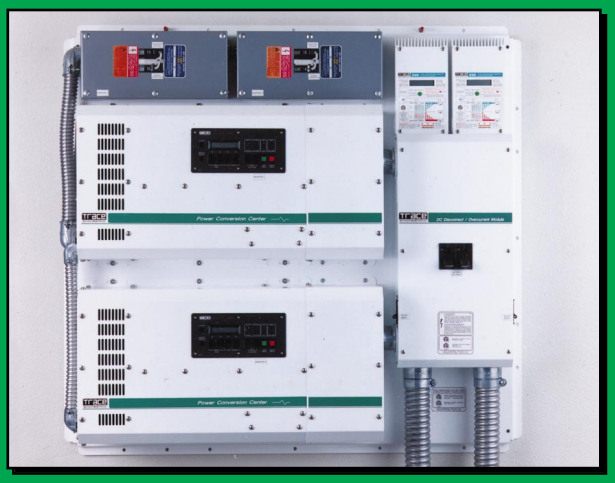

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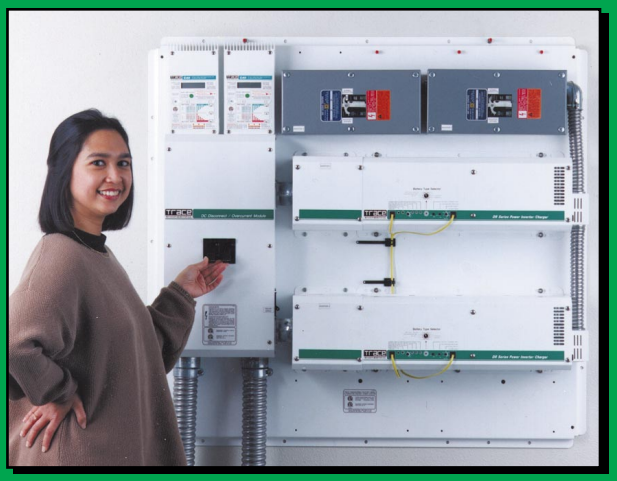

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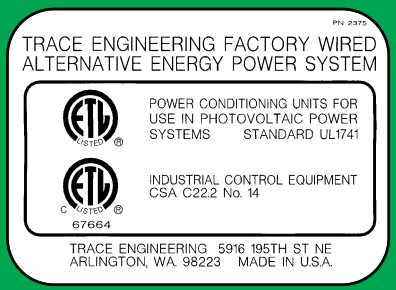

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HORNS -OR- SHOELACES ?

THAT IS THE QUESTION

Mike Islam

As a law graduate, I used to work for a firm of solicitors in London, England. Ever since a child, however, I dreamt of living with Nature and so my escape from the rat-race to the heather hills of Rogart in Sutherland, Scotland was inevitable.

During my years restoring my derelict cottage, I felt increasingly close to Nature and relished its beauty; such as seeing Bens More and Klibreck on the horizon, riding in grim isolation through the last embers of a sunset, the rare privilege of having deer graze in front of my cottage, those moonlit nights which turn the landscape into a hauntingly beautiful deep blue, and, perhaps the most spectacular of all Highland scenes, waking up to see the mountain tops floating on an ocean of mist below me. “How wonderful the world is!” I thought. But deep down I knew all was not well.

Although I had well and truly escaped the rat race, I had not, however, been able to escape the numerous disturbing reports on my radio about global warming and destruction as a result of the comfortable way we humans live, our consumer life-styles, and the resulting emission of countless million tonnes of pollution every day, all over our planet. The precise statistics about the catastrophic environmental damage, as established by the world’s scientists in the Environmental Digest, overwhelmed me so that I could not understand why all life on earth has not already been killed off. And living where I do, as opposed to living in a concrete pigeon-hole, serves me as a constant reminder of what exactly we are killing off. I began to liken my species to a swarm of locusts which consumes and lays waste to a field of crops. And I realised, more than ever before, the desperate need for humans to live in harmony with nature, but I also had to make a start, however modest its effect, within the four walls of my own back yard. I was not going to use mere words to complain about it or, worse still like almost everybody does, bury my head in the sand and pretend that the world’s scientists just happen to be mistaken. I felt I needed to know, when I die, that I was a certain someone who “grabbed the bull by the horns.”

Having, after two difficult years, completed the restoration on my cottage, I addressed the environmental problem by vowing never to drive a car again, and by putting my heart and soul into a new and exciting challenge–alternative technology. Named this way because machines and appliances based on this principle are driven by the non-polluting forces of nature such as the pushing power of the wind and flowing water, and by the heat and light of the sun–an environmentally friendly “alternative” to the use of machines powered by smoke and toxin-releasing fuels such as petrol, oil, coal, and wood. In short, wind, water, and sun create energy too, but without the pollution.

As Scotland has a high wind resource, I decided to build a wind generator, but one wasn’t going to be enough for all my electricity needs, especially heating. There was nothing else for it–I had to build my own domestic wind farm. As if that wasn’t enough of a challenge for my academic background, I had to, due to my means and remote location, build it wholly out of scrap materials, and of course also without the use of a car.

Needing some form of transport for my prospective wind generator materials, I made a trailer for my bicycle by reshaping an old metal-framed school desk and then welding to it wheels from a broken wheel chair. My environmentally friendly vehicle complete, I made countless trips over several months to refuse skips and scrap yards far and near, sifting through heaps of rubbish. I pushed my loads up countless hills, as I live 600 feet above sea level. It was, looking back on it, hard and dirty work and I often felt like a scavenging vulture. Indeed, after a while I was even beginning to live and look like one—especially when it rained! I was grossly neglecting myself but my hopes and enthusiasm for a sustainable future kept me going.

Above: Mike Islam shows off his three wind turbines, made from scratch.

But gradually and perhaps inevitably, I began to tire physically and mentally because making the trips had taken their toll, and I had scant little to show for my efforts and waning enthusiasm. Furthermore, I had no workshop, only my bedroom floor to work on, and all to often I would spend hours searching for misplaced parts which would usually surface in my bed the following morning! And quite apart form my primitive conditions, it has to be said that Mike was making an unmitigated "balls up" of the work! According to my neighbour, "Accountants don't make the best shipbuilders." As I had once been a lawyer, I took the point because my objective and meagre means of achieving it made me, too, feel as if I were a million miles away from building a wind farm. I was beginning to wonder whether my stubborn infatuation to persist in this was a sign of madness. Perhaps I would become a scruffy and eccentric Highlander living remotely in his cottage with only his bottle of whisky and his illusions to befriend and comfort him.

It was certainly looking that way because in the end the work proved to be too much and as the days were getting darker, so were my moods until I broke down, craving sleep for up to 20 hours a day. My doctor tried to assure me, pursuant to repeated blood tests, that my condition could only be due to fatigue from depression and not because I was, as I was beginning to suspect, dying of an incurable illness. After eight months without any improvement in my health I felt it was time to come to terms and actually live with my chronic fatigue as a long-term or permanent condition. This meant being realistic about what I could and couldn't do, and not taking on any more challenges. So I wrote off my project and no longer felt pressured to make any headway with it at all. At most, I only pottered around with it, doing whatever little I felt like doing since it was conveniently close to, or sometimes actually on my bed! "Windgenerators? What do I care anyway!" I would scoff.

My uncharacteristically indifferent and lax approach, however, saw me doing increasingly more work every day. Things were, for the very first time but ever so slowly, coming together. Also, the advent of spring brought new life to the natural world and some of it seemed to be rubbing off on me too. The days were getting longer and before I knew it, my hopes, enthusiasm, and energy were restored. I felt I was on the crest of a wave and, wanting to exploit this, I did a bit of a "fast forward." Propellors were carved at a furious pace, it was good to see welding sparks flying again, even my anvil would have cried out for mercy

were it able to do so, the muddled miles of copper wire I had fished out of old motors and dynamos were painstakingly recoated with resin and made into neat electricity-producing windings, and fibre-glass covers were cast in moulds to keep the machines dry from our notorious Scottish storms.

By now the windgenerators were taking shape and delivering, on testing, hefty sparks of electricity. The end was, at long last, in sight until I suffered another setback—full time employment! Though this time it was just a matter of patience (and not energy, even though I was cycling 150 miles each week to and from work in Brora), because after another two months of weekend work on my project (and some two years after the day I had started) the wind farm was completed and ready for testing. There was an eerie stillness in the air that afternoon as I waited for the wind knowing that it would bring with it a Judgment, not just on my project, but on me too. So, with apprehensive anticipation, I awaited the final Moment of Truth. Later that evening, when I heard that familiar sound of the wind whistling against my roof gutters, I eagerly rushed out of my cottage to look. But standing in front of my wind farm and watching it spinning dizzily, I found myself sighing and slowly shaking my head. After all I had been through, I could no longer bring myself to feel happy—only relieved.

My electrical generators are purpose-made to be powered by the wind and are almost comparable in design and power output to their commercial counterparts. They are not ready-made vehicle generators which some people modify but then find they are inferior as they are designed to be driven, not by the wind, but by a fast-revolving petrol or diesel engine.

If anyone were to dismantle my machines they would find, amongst other things, steel profiles from an old metal bed, Range Rover wheel bearings, street lamp covers, plywood from an old games table, sheet metal from an old fridge, lampshades, bicycle wheels and aluminium street signs. The propellors are bolted to and turn the electrical (permanent magnet) generators in the wind, which then produce electricity. And as a way of protecting themselves, the windgenerators automatically turn way from dangerously high winds.

The smallest machine, with a six foot propellor, gives up to 400 Watts at 12 Volts, which is enough for lights, a fridge, and a TV and the power for these is stored in a bank of 12 Volt batteries when the wind is blowing. The biggest machine weighs 150 pounds, has a ten foot propellor and turns out over 2000 watts at 240 volts—enough to heat two medium-sized storage heaters and a hot water immersion heater, as well as to power domestic appliances directly.

Sometime after completing my alternative energy project I happened to get talking to a couple of elderly tourists at my local train station down in the valley. The man asked me, “So what do you do up there in your remote cottage in the hills?”

“Me? I make WINDGENERATORS!” I replied, feeling rather proud and content with myself. But I said it slowly to avoid any risk of misunderstanding because some people aren’t too sure exactly what that means. Anyway, he nodded and appeared, in actual fact, to be quite impressed. And so he should be I thought! A couple of minutes later, however, this wife asked me the same question, “So what do you do up there.…?” Well, before I could open my mouth to repeat myself, the man lent over towards her and yelled into her ear with his Swiss accent, “He generates VIND, Margarette, he generates VIND!!!”

“Ooh, how painfully embarrassing!” I thought, but that wasn’t half as embarrassing as having a crowd of people (who happened to be standing on the same platform), turning their heads very smartly in my direction. Of course by now, I was frantically trying to find a suitable hole in the ground! But, what was also funny was that, upon being told that I “generate VIND”, the woman then nodded her head vigourously as if that were a proper, recognisable profession! God knows what she thought I was, perhaps some sort of local politician—or lawyer?

But on a serious note now, it should not be forgotten that the very reason for this project was due to my committment to try, as far as humanly possible, to live in harmony with Nature. This is based on my view that if one lives, one must also let live. Unfortunately for Nature, pollution kills. I often wonder how, if God really does exist, He regards the true role we are playing on His planet as opposed to the role we like to think we are playing. Would He really love us and be on our side? I also wonder whether we, as a species, deserve to live—given what we are doing to the planet. Whenever I put this issue to people, they never grab the bull by the horns and address it fairly and squarely. Instead they often look down, apparently showing more interest in their shoe laces. So the question I would like to leave for the reader is, “Is it going to be ‘horns’ or ‘shoe laces’ for you?”

Access

Author: Mike Islam, “Anchork Point”, Rogart, Sutherland, Scotland, IV28 3YE, United Kingdom

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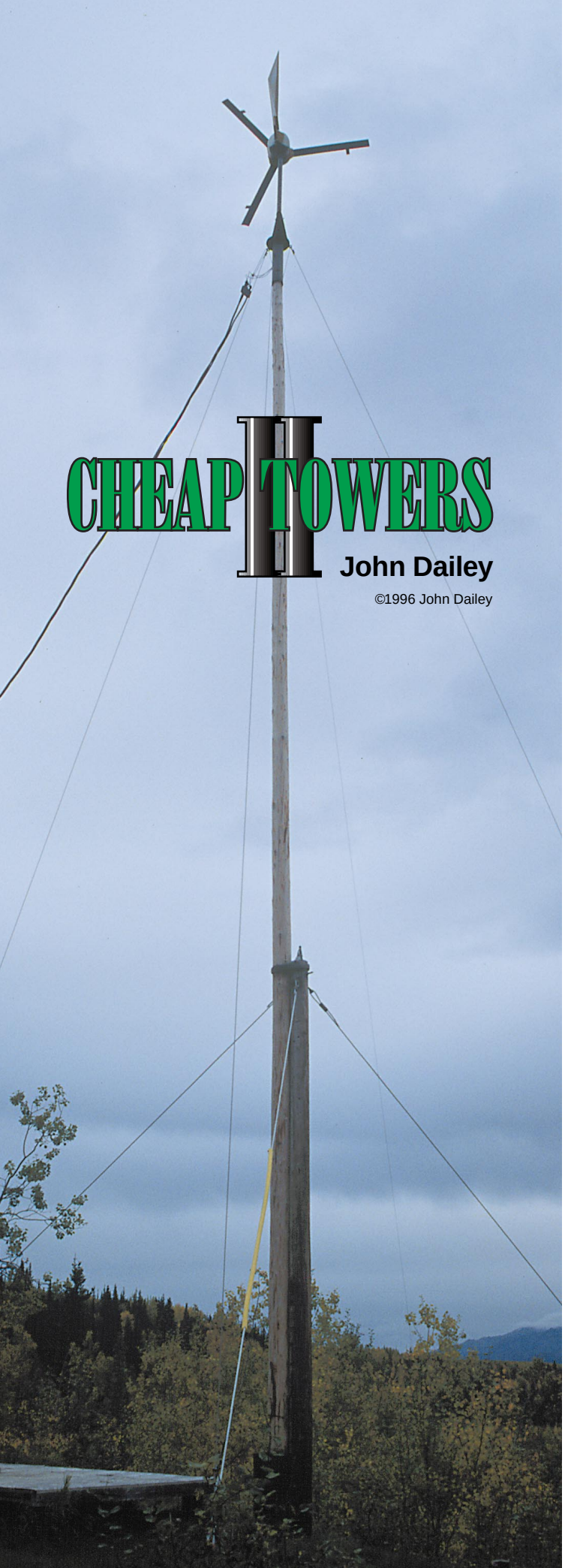


CHEAP TOWERS II

John Dailey

In the spring of 1990, we put up a Windseeker II to evaluate the feasibility of wind power. Here on our homestead in the foothills of the Alaska Range, we get frequent blows lasting a day or two, and then calm for a week or so. We constructed a 50 foot tower from a 20 foot utility pole and three lengths of 2 inch pipe (see HP 28 page 26). After two years of operation with our Windseeker II, we felt that our local wind regime merited a larger machine.

After a false start with a machine that was not really designed for our rugged mountain winds, we took the plunge and bought an 850 watt Bergey. This Bergey was selected to withstand the rigors of our 80+ mph Chinook winds and has lived up to its sterling reputation. This bigger machine needed a stronger tower, and after reading Mr. Wind's great articles on tower height (see Mick Sagrillo's Econ 101 and 102, HP 37 and 38), we realized an extra 10 feet would greatly increase our output.

This is one person's solution, and not appropriate for all. Be sure it is right for you and that you have access to the appropriate materials and tools. If you have any doubts, consult qualified persons.

Any tower type, whether free-standing, guyed lattice, or guyed pole, must allow the owner/operator access to the wind machine for periodic maintenance. Generally, pole towers are lowered, not climbed, and the machine is then serviced on the ground.

These towers can be built from a variety of locally available materials. In our neighborhood, there is an abundant surplus of old 20 foot utility poles from the abandoned Anchorage to Fairbanks telegraph line, so one of these poles was the starting point for us. Our pole is about nine inces at the base. Use your imagination to take advantage of the materials available to you locally, but be careful to get it right; you don't want to wait for a nasty blow to realize that you underbuilt. By then, it's too late to do anything but wring your hands and stay out of the way as your tower and expensive machine come crashing down.

A Note about Safety

Although towers that lower your genny to the ground for service are in many ways safer than towers you must climb, remember that falling bolts, forgotten tools, etc.

Above: The Dailey homestead in the foothills of the Alaska Range, showing the Bergey 850.

can still dent your head when falling 60 feet. So, unless you are tougher than Wyl-E-Coyote, WEAR A HARDHAT! During the critical raising and lowering phases, remove all pets and kids from the area: you'll have enough to worry about. (See safety sidebar.)

You Can Build It!

The design of this tower is simple: a 20 foot utility pole is permanently guyed and serves as a fixed gin pole. A 60 foot wooden pole hinges at 1 foot up the from the base of the gin pole. The pole swings from a horizontal access position up to vertical and is then clamped with a heavy nylon strap with a ratcheting binder to the top of the fixed utility pole. Additional guys run from the top of the tall pole down to the same ground anchors that secure the utility pole guys. All guy wires are 3/16 inch. A chain saw winch (rush right out and buy one of these gems, if you're a homesteader and don't already have one…), or tractor, pickup truck, etc., can pull the main pole and attached generator up or down. The winching cable should also be a minimum of 3/16 inch.

After you have selected a good wind site, lay out your tower location and where you will locate the three guy anchors. The minimum guy radius is 50% of the tower height if you have a small field, but 75% is better. The wider the guy radii, the more horizontal the supporting guy wires are, and the less is the downward, buckling force on the tower during strong winds. Bergey recommends a simple method to eliminate plotting angles for the tower foundations (see guy sidebar).

Once you have laid out the positions for the guy anchors and the tower, the next step is to secure the guy anchors so that they cannot pull out. Our soil has good shear strength so we were able to use auger type anchors (excavated and re-buried). No concrete deadmen were required. Evaluate you own situation, though, and make sure that they will not pull out. A small backhoe is very valuable here, although (we can only imagine that) a strong back will get the job done, too…

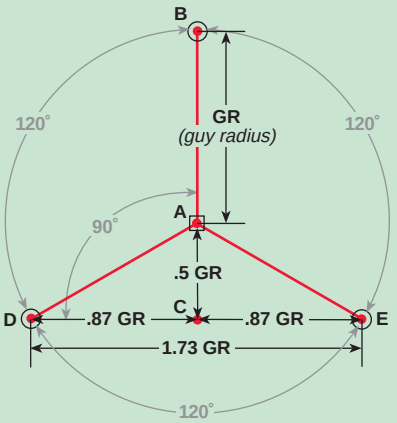
To install the permanent utility pole, excavate and pour one foot below grade an approximately 2 by 2 by 1 foot thick concrete pad with some rebar incorporated. The base of the utility pole will be anchored laterally as it is buried a little. Tamp the soil in around the pole above the pad. If you have very rocky, well-drained soil like ours, you will not even need the concrete pad, but pour the pad if you need to. You do not want the tower settling later and slacking your guy wires. Plumb this permanent gin pole, and tighten the guy turnbuckles.

Fabricate a hinge bracket and bolt it to the base of the utility pole, about a foot above grade. We used two pieces of 1/4 by 14 by 18 inch plate steel with a piece of plate welded across the outside bottom to keep them parallel. This hinge bracket should be bolted through the permanent gin-pole in three places with 1/2 inch bolts.

For the tower pole, you need to find a long, straight, strong pole. You can sometimes find these poles where there is crowded tree growth. These trees seem to reach tall and straight towards the sun, with little bend or taper. We used a peeled Sitka Spruce pole. Select a strong straight pole from the appropriate local species and peel it, but don't worry about treating the wood. (*ed. note: We can't overemphasize the need to choose a strong spar. Some tree species may not be up to this task, and others could have weakness because of large knots or other flaws. Also, do not try to use heavy wind machines with this design. The Bergey weighs 86 lb. If*

120˚ Guy Anchor Positioning

exerpted fron BWC installation manual



AB = GR *(guy radius)*
AC = 0.5 GR
DC = 0.87 GR
CE = 0.87 GR
DE = BE = BD = 1.73 GR
∠ACD = ∠ACE = 90˚
∠BAD = ∠BAE = ∠DAE = 120˚

= Tower Base
= Guy Anchor
= Measure Point
= Guy Cable

To Eliminate the need to plot angles in laying out the tower foundations we can resolve the equilateral triangle into two perpendicular lines as shown in figure ?

The three anchors are at points B, D, and E, the tower's base pad is point A, and point C is a reference point. The distance A-B (from point A to point B) is the guy radius (GR). For normal installations, GR is approximately 60% of the tower height. The distance D-E is one side of the equilateral triangle and is equal to GR X 1.73. One half of D-E is C-E, where point C is the center of D-E. C-B, and thus C-A, are perpendicular to D-E. The length of C-A is equal to 1/2 of GR.

These relationships make it easy to lay out the anchor points and base pad with only a tape measure. You will need a 30 meter (100 feet) tape measure, a hammer, and five stakes. Starting at the center point A, measure out a distance equal to GR and stake it. This will be point B. Put another stake at point C by measuring a distance equal to 1/2 GR along the line connecting points A and B. Now estimate a perpendicular line through point C to find and stake points D and E. Points D and E can be checked and adjusted by making sure that distances A-D and A-E are equal to GR. A final check can be made by confirming that distances B-D, D-E, and E-B are equal.

Right: Detail of the stub tower assembly and the Bergey 850.

Below: Top of the gin pole showing nylon strap, guy attachment, and fairlead pulley.

you have any questions or doubts, consult a structural engineer.) You can put it up green and treat it with a wood sealer when you lower it next. If the butt of your tower pole is larger than the slot in the hinge bracket, you will have to shave it on both sides to fit. Ours shaved down to about nine inches. Drill a 1 inch hole in the pole and bracket, and use 1 inch o.d. steel pipe as a hinge pin.

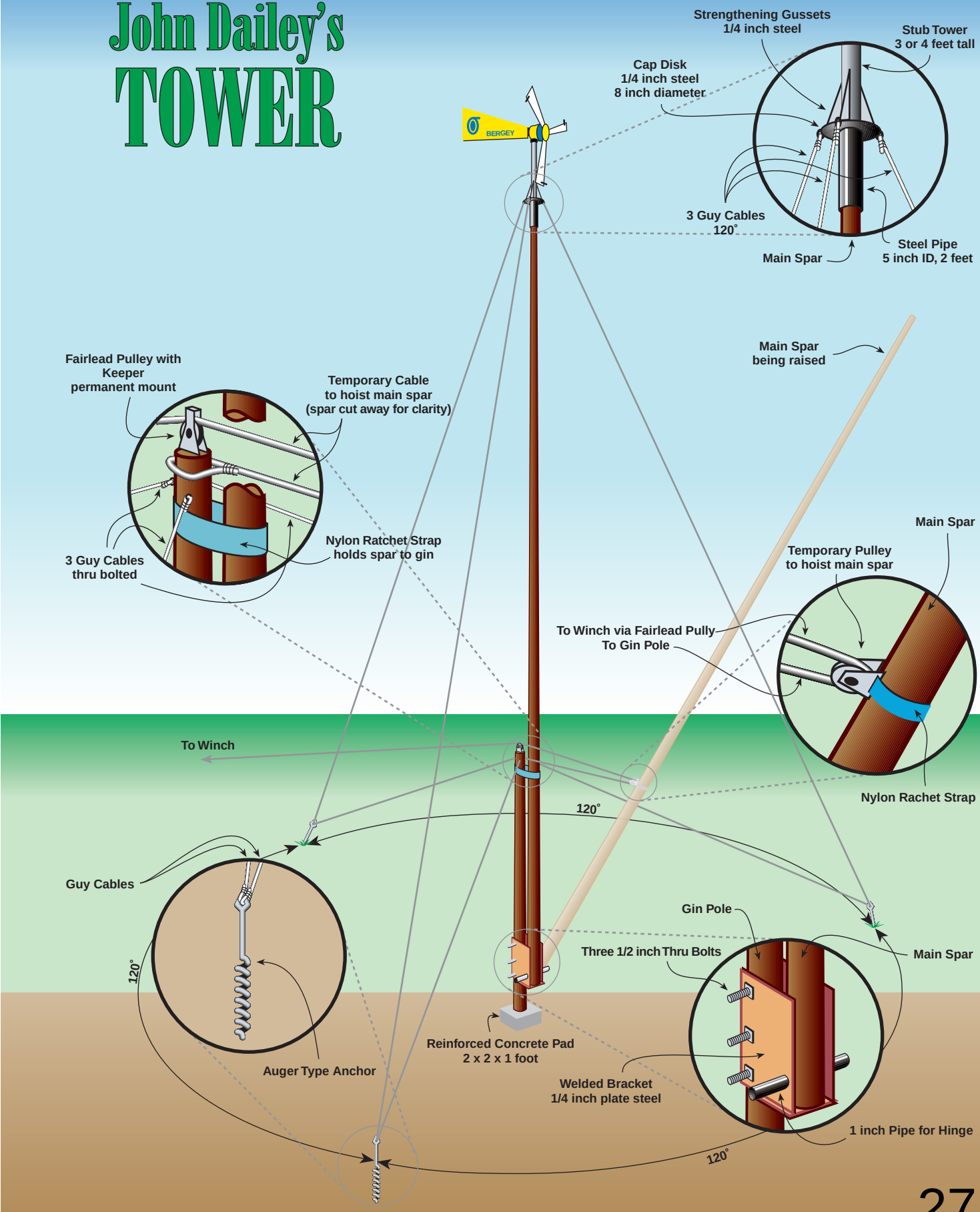
Above: Base detail showing 1/4 inch plate steel bracket, the shaved spar sides, and 1 inch pipe hinge.

Right: Detail of auger type guy anchor.

Test Your Work

Before mounting your precious generator, try raising and lowering the pole. Mount a small fairlead (a pulley/guide to protect the cable and ease its travel) on top of the 20 foot utility pole. The winch cable will travel over the fairlead, around a pulley block attached to the tower pole, and back to the top of the gin pole (see diagram). This doubling back of the winch lead cuts the speed at which the pole is lowered in half and also halves the necessary pulling force. Do not drill thru the tower pole to mount the pulley block, as that could weaken it at a very critical spot. We temporarily attached the pulley block to the tower pole with a heavy nylon strap. When lowering the tower, be sure not to let the winch freewheel out. Your pole could quickly get away from you.

John Dailey's TOWER



Tower Safety

excerpted from BWC installation manual

The primary concern at any installation should be for the safety of the individuals involved. Tower work is inherently dangerous, and there is always the potential for injury. If everyone is careful and remains aware of the dangers, however, there should be little risk. The following rules should be observed *ed. note: Many of these rules apply only to scalable towers, but we thought they were all worth mentioning*.

1. Persons not directly involved in the installation should stay clear of the work area.
2. All persons on or in the vicinity of the tower should wear OSHA approved hard hats.
3. Tower work should be done by or under the strict supervision of trained personnel.
4. Never construct a tower near utility lines. If any portion of the tower or equipment comes into contact with them, serious injury or death may result.
5. Anyone working on the tower should use a lineman's belt and a tool belt.
6. Never carry tools or parts in your hands while climbing the tower. The use of a hoistable tool bucket is recommended.
7. Keep the number of tower trips and the amount of work to be done on the tower at a minimum.
8. Never stand or work directly below someone who is working on the tower.
9. Never work on the tower if alone at the site.
10. Never climb the tower unless the machine is furled and the alternator shorted.
11. Stay clear of the tower in the presence or the possibility of thunderstorms, high winds, tower icing, or severe weather of any kind.

As you begin to raise the pole, you are lifting considerable weight compounded by the steep angle of pull when the pole is horizontal. This will be made even greater when you add the weight of the generator. A safe way to test your winching system and the bending strength of the main spar is to suspend a weight that is 1 1/2 to 2 times the weight of the wind machine from the top of the pole to simulate the wind generator. Slowly start winching the tower up. If the winch is not up to it or the pole breaks, you will find this out safely, not as your generator comes crashing down.

Final Installation

To mount the generator, build a stub tower to fit down over the top of your pole. The exact dimensions needed to mount your generator will be given by the manufacturer. We found that a 2 foot section of 5 inch i.d. pipe slip-fit snugly over the top of our pole. If it is not very snug, a thru-bolt will make sure that it will stay. We welded an 8 inch disk of 1/4 inch steel to make a cap on the top. Three links of chain at 120˚ intervals were then welded to the cap to provide attachment points for the tower (upper) guy wires. The 3 or 4 foot long stub is then welded onto the cap disk, with strengthening gussets if needed. To get the stub tower plumb, it helps to have a transit because there is very little reference when you are looking up. Do this when the tower is raised without the generator, and adjust accordingly.

Above: The Dailey home showing off the rest of the RE system.

Mount the wind generator and bring the power wires down the pole. Make sure to provide strain relief for the wires as they are quite heavy. We ran the power wires directly from the stub tower over to our house, down the wall, and into the basement. A better solution may be to cable-tie the wires to a guy wire.

Winch up the tower pole with the generator and use a 2 inch trucker's load-binding ratchet strap to bind the tower pole to the top of the fixed gin pole.

We added an extra upper guy cable way out from the normal guy directly to the south, where the snot-kicker winds always come from. We recommend it if you, too, have a prevailing wind. It provides added security when things get wild.

When the wind is howling, we're warm and snug inside, and enjoying all that electricity all night long!

Access

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Photos by Kate Salisbury

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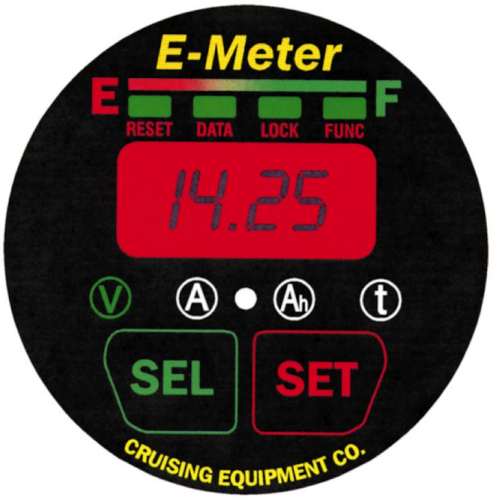
Things that Work!

Things that Work!
tested by *Home Power*

Cruising Equipment's E-Meter



Tested by Richard Perez and Ben Root

The E-Meter is an instrument which measures battery Ampere-hours, voltage, current and the time remaining until the battery is fully discharged. The E-Meter also measures many other battery parameters, such as efficiency, average depth of discharge, deepest depth of discharge, and number of recharge cycles. All this in a small and easy to install instrument costing under $200.

E-Meter Specifications

The E-Meter is an electronic instrument that measures a battery's state of charge. The amount of energy remaining in the battery can be displayed as an Ampere-hour number on the seven segment LED display, or as a percentage of battery capacity. The same info is also displayed graphically on the meter's four segment LED bar graph. The meter also measures system voltage with a resolution of 0.05 VDC in 12 Volt systems and 0.1 VDC in 24 Volt or higher systems. Current is measured via a 500 Ampere, 50 milliVolt shunt supplied with the E-Meter. Current is measured with a resolution of 0.1 Amperes below 40 Amperes and 1.0 Amperes above 40 Amperes. The time remaining function tells the user how long the battery will last at the present discharge rate and battery capacity. Time remaining is expressed in hours with a resolution of 0.1 hours.

The E-Meter is powered by the battery which it is measuring. Input voltage can be in the range of 9.5 to 40 VDC. Input current varies from 50 to 150 milliAmperes depending on display selection and ambient light (the display self-adjusts the intensity of the LEDs to match ambient light conditions). There is a low power "sleep mode" of 28 mA for systems left unattended. The E-Meter can be used in battery systems up to 500 VDC with an optional voltage prescaler.

The diameter of the E-Meter is 2 inches (50 mm). Its outside bezel diameter is 2.5 inches (63.5 mm). The meter is 3.15 inches (80 mm) deep and weighs 8 ounces (227 g).

The E-Meter will support a number of optional features. An optional RS232 port allows the meter to communicate with a microcomputer for data logging. Cruising Equipment also makes a stand alone data logging module for the E-Meter (which in turn also has an optional Global Positioning System [GPS] module for tracking speed and position in vehicles such as sailboats and electric cars).

The E-Meter comes with a limited warranty of 18 months. Included in the meter's price is 15 minutes of telephone tech support from Cruising Equipment. Retail price of the E-Meter is $199.95.

Documentation and Installation

The documentation supplied with the E-Meter is extensive. It contains a tutorial about the battery parameters which the E-Meter measures. The installation diagrams are extensive and thorough. The manual is small in size (4.25 by 5.5 inches) and

contains 40 pages. We had no trouble either installing or programming the E-Meter—the manual led us step by step.

We installed the E-Meter on our main system's pocket plate, nickel-cadmium battery (150 Nife HIP10 cells in series/parallel for 1500 Ampere-hours at 12 VDC). There are only five wires required to hook up the E-Meter. The meter is designed to panel mount in a 2 inch diameter hole. Since making a 2 inch hole challenged our local technology, we used a standard meter bracket for the auto parts store for $2. Installation and setup took under one hour and is well within the capabilities of anyone who can read and run a screwdriver.

The user programs the E-Meter with the battery's capacity in Ampere-hours and at what voltage and current the battery is considered to be fully recharged. After this the E-Meter works automatically.

E-Meter Performance

We set the meter to scan its four basic measurements. This means that each parameter (Volts, Amps, Amp-hrs, and time remaining) flash across the display each for a duration of four seconds. The meter is easily visible from across the room and at night. I find the bright LED display much easier to read (especially at a distance) than the LCD type of display.

We parked the E-Meter on Volts and Amps functions and checked its accuracy against a Fluke 87 Digital multimeter. We found that the measurements made by the E-Meter were accurate to within Cruising Equipment's specifications (voltage 0.6%, amperage 0.8%). We checked the E-Meter's Ampere-hour accuracy against Cruising Equipment's Amp-Hour +2 meter and a Link 2000, both of which have been calibrated with a Fluke 87 in record mode and a stop watch. Ampere-hour measurements made by the E-Meter agree with SOC measurements made by the other two Ampere-hour meters (each of which costs over twice what the E-Meter does).

The E-Meter actually computes the battery's electrical efficiency using battery historical cycling data. The E-Meter recomputes battery efficiency every time the battery is cycled more than 10% of its capacity. We find this battery efficiency data to be very useful. When the battery's efficiency drops, its time to do an equalizing charge. The efficiency data also shows greater battery efficiency on shallow cycles and less efficiency the deeper the battery is cycled. And the E-Meter performs these efficiency calculations by measuring and storing data about the battery under test. Its microcomputer actually "learns" about your battery and how you use it.

The E-Meter also supplies historical data about the battery's use. It makes measurements of the average depth of discharge, the deepest depth of discharge, and the number of recharge cycles that the battery has undergone. This historical data is very useful in assessing a battery's capabilities under real world service.

Conclusion

Over the last fifteen years I have tried dozens of meters to indicate our battery's state of charge. We've had walls festooned with instruments. If I had to choose just one meter to operate our RE system it would be Cruising Equipment's E-Meter. It's accurate, easy to use, and inexpensive.

Cruising Equipment has became the leader in battery state of charge instrumentation with their first Amp-hour meter in 1990. Their latest instrument, the E-Meter, offers useful battery monitoring for all types of systems—from sailboats to PV systems and from electric cars to wind generator systems. If the system uses a battery, then the E-Meter is the instrument to ride herd on that battery. I'm amazed that all this technology can be packed into such a small, easy to use, package. I'm flabbergasted that the retail price of the E-Meter is so low and still includes the 500 Amp 50 mV shunt (normally over $30 retail by itself). Good work, Cruising Equipment, and Thumbs Up!

Access

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The Advent of the Sealed Nickel Cadmium Cell

William Farrell

Listed below are the "Basic Chemistry 101" reactions inside a Nickel Cadmium Cell on Charge or Discharge. The "true facts" are that these formula only satisfy those folks who like to see equations nicely balanced on each side. They also like to see recognizable compounds. What is really going on inside the cells is much harder than this and most of it is still unknown. This is true for all battery systems.

Charge, Overcharge and Discharge Equations for the Nickel Cadmium Cell

Charge, Positive Plate

$2Ni(OH)_2 + 2(OH)$ yield $2NiOOH + 2H_2O + 2e$

(Nickel Hydroxide) yield Nickel Oxy Hydroxide

Overcharge, Positive Plate

$2(OH)$ yield $_{1/2}0^2 + H_2O + 2e$

Charge, Negative Plate

$Cd(OH)_2 + 2e$ yield $Cd + 2(OH)$

Cadmium Hydroxide yield Cadmium Metal

Overcharge, Negative Plate

$2H_20 + 2e$ yield $H^2 = 2(OH)$

Discharge, Positive Plate

$2NiOOH + 2H_2O + 2e$ yield $2NI(OH)_2 + 2(OH)$

Nickel Oxy Hydroxide yield Nickel Hydroxide

Discharge, Negative Plate

$Cd + 2(OH)$ yields $Cd(OH)_2 + 2e$

Please note the General Fuzziness around the (OH)'s,

These General Equations whetted the appetites of the entire electrochemical community when the Nickel Cadmium system was first investigated, back in the early 1900's. There was the hint that the Nickel Cadmium Cell could be sealed to be maintenance free.

In the pre-war era things settled down to making Nickel Cadmium Cells for Traction, Miner's Lamps, Railway Signal, and Car Lighting Batteries. The Great Depression slowed the pace of research, and companies concentrated on "staying alive" with profitable products.

I don't want anyone to write to me about pre-WW-II, during-WW-II, or post-WW-II German or Swedish or Czech searches for the Sealed Nickel Cadmium Cell and/or Battery. I know all about those efforts.

The Standard Schoolbook Formula shouts out that there should be ways to effect an equilibrium between energy, gas, and material that would allow "sealing up" the Nickel Cadmium cell to stop the consumption of the water, in the electrolyte.

The Neuman Cell

The Facts of the matter were that the only available sealed Nickel Cadmium cell (during the '30's) was the "Neumann" cell, available in Czechoslovakia. This particular type of cell was made with a sort of fine wire "Brillo pad" made of a compressed mat of fine Nickel wire for the positive and a compressed mat of fine Cadmium wire for the negative plates with plenty of liquid potassium hydroxide electrolyte. The separator appeared to be a strong filter paper of some sort. Sometimes they used sodium hydroxide for the electrolyte. The active Hydrates, of the two metals were "formed" using the outer surface of the "Brillo"-like wires.

The "Neumann" cell was available for flashlights. This type of cell was used because Manganese Dioxide Ore (the positive electrode for the LeClanche' cell) was not available. The "Neumann" cell had a serious problem. Typical internal gas pressure at the End Of Charge was about 800 to 1,200 psig.

Can you imagine installing a pair of these explosive beauties in a hand held flashlight to be used by your Mom? Call me Lefty.

Swedish Patents
Basic International Patents, that looked as though a real breakthrough was coming, were developed and issued to the Swedes. Nothing came of them. I always felt that the Swedes left the lab and disappeared into a shot glass of Akaavit while resting on their Patent Papers. They seemed to just forget the whole thing as being of little interest and no commercial value in Sweden. Sweden didn't have enough of the Nickel and Cadmium raw materials to worry about, anyway.

In the late 40's and 50's the Swedes woke up and found that they could collect sums of money for licensing these patents. They still do.

Germany
In Germany, lead became a critical item during and after the Blitzkreig days, and Lead Acid engine starting batteries were high on the critical list for both ground equipment and aircraft. Many of the most sophisticated German aircraft were still equipped with the old "hand cranked inertia" starters using a mechanical flywheel for the energy to start the engines. These devices became extremely heavy as engine horsepower got larger and larger. Carts were built with the flywheel mounted on the cart with a spline fitting that fit into a hole in the aircraft.

The Germans developed and built Nickel Cadmium Aircraft Batteries using thick plates of a base sinter made of copper granules. This sintering process was already well understood from the sintered bronze or copper "Oilite" bearings. These flat sintered copper plaques were nickel plated after sintering. The supposition was that the plating would eliminate the formation of sharp dendrites at the negatives that would short out the cell. Unfortunately, the nickel plating of the copper particles doesn't reach deep into the matrix of the sintered mass. These batteries had the unfortunate problem that Copper was not noble enough to be used for the Negative plates. Once the active materials had been impregnated into the sintered copper matrix and a cell assembled, the Negative plates grew little copper dendrites (spikes) through the separator materials and shorted out the cells.

This dendrite growth also contributes to the short life of the Silver-Zinc and the Nickel-Zinc cell systems, today. I felt that one of the GE Chemists was very close to making satisfactory Nickel Zinc cells back in the late 60's. He called them Zinkels.

This dendritic mode of failure was not well understood back in the 40's. This sintered copper plaque type of Nickel Cadmium Battery was made for use in German Pursuit Aircraft. Pursuit Aircraft must be ready to "scramble" on short notice. There can't be any waiting around for the Inertia Start Cart to show up.

The Dendrite Failure mode was accentuated and accelerated by long continuous overcharge at "trickle" rates. This was the normal mode while the planes were resting on the ground.

Post War
At the end of WW II, the Americans "liberated" a couple of German engineers from the German Nickel Cadmium facility. They were shipped off to the USA. Like "our" early rocket scientists, they developed the technique for sintering Carbonyl Nickel Powder into porous sheets on a nickel plated steel screen. These very thin flat plate sintered "plaques" were impregnated with Nickel and Cadmium salts and were used in the first USA Nickel Cadmium cells.

In the Government's infinite wisdom, they assigned the Commercial and Military development of this exciting new electro-chemical product to Sonotone Corp, a manufacturer of Hearing Aids and Sub-miniature Vacuum Tubes. The Vacuum Tubes were to disappear to the onslaught of Bell Labs and the introduction of the Transistor. As a matter of fact, the Sonotone hearing aid went the way of the Dodo also. The factory where this work was done is now a paper weight.

The factory where the first Military Sintered Plate Nickel Cadmium cells and batteries were produced has been razed by the EPA and the Superfund. Grass has been planted where the 130,000 sq ft factory once stood, in Cold Spring, New York, adjacent to the Mighty Hudson River. The site is now free from any and all Cadmium pollution.

In France, SAFT is an acronym, it stands for "Societe Accumulators Fixes et Traction", which is why I abbreviate the name to an acronym (SAFT). SAFT has been manufacturing conventional Tubular and Pocket Plate Nickel Cadmium Cells for the Power Station, Mining, Traction and Railway Industries for almost 75 years. They also manufacture some Nickel Iron Cells. At the conclusion of WW-II, as a part of the War Reparations, they managed to secrete one of the top German Nickel Cadmium Manufacturing Engineers out of war torn Germany. With the awarded War Damage Reparations they also got some equipment from the German facility. All this stuff, and the engineer went to work at the SAFT factory at Bordeaux. This engineer's job was to learn/teach how to sinter metals other than copper and bronze. He especially concentrated on sintering Nickel particles generated from the Oxidation of Atomized Nickel Carbonyl. This particular nickel particle exhibits extremely high surface area to weight ratios. These particles are extremely difficult to

examine with a conventional optical microscope. It wasn't until the advent of the Scanning Electron Beam Microscope (ca. 1970) that the inferred shape (an airy Christmas Tree) was confirmed. The inferred shape had been painstakingly developed by embedding the particle in a plastic matrix and then polishing away the upper surface of the particle and matrix in tiny layers. Photos were taken at each "slice". It amounted to a sort of a mechanical MRI. When all the "slice" photos were assembled the shape "sort of" revealed itself.

In due time these Nickel particles were successfully sintered into thin sheets, using a support structure of either perforated nickel plated steel, electro-formed nickel sheet, or nickel plated wire screen. The sintering temperatures were very high and difficult to control to the degree of precision necessary. Later developments of high current Silicon Controlled Rectifiers simplified the temperature control problems. The finished sintered plaques were about twice as thick as a matchbook cover. The porosity of this material was unbelievable, it was well into the 80% porous range, or beyond. The technique used to examine the porosity was Mercury infusion into the porous mass under very high pressure. This method was not entirely satisfactory as the Mercury had a tendency to amalgamate with the nickel particles, if the nickel surfaces were very clean. As a point of interest, common window screen is about 50% open. The rest is wire.

Active material in the form of slightly acidic concentrated Nickel Nitrate was used for the Positive Plates and concentrated Cadmium Nitrate was used for the Negative plates. These materials were forced into the interstices (interstices are the spaces between the potatoes in a basket of potatoes. You can pour in a lot of shelled peas or corn into the interstices, even though the basket appears to be full of potatoes). The Nitrates were converted to Hydrates by soaking the plates in Lye after impregnating. The process (for the positives) is very touchy and is somewhat akin to kissing a duck in the hind end without touching the feathers. At the conclusion there were useful Positive and Negative cell plates. After this chemical processing, the plates were "formed" by alternately charging and discharging in a lye bath. This formation is usually done using only a negative or positive with a plain metal "dummy" plate as the other polarity.

The awful truth was that these plates weren't very good. The products didn't measure up to the nominal electro-chemical capacity of the standard SAFT industrial product or even the Nickel Iron Edison Cells. The other problem was that the cells absolutely refused any attempt made to seal them up.

The Lighter at the End of the Tunnel

As Paul Harvey has been known to say, "Here's is the rest of the story."

SAFT, is a part of Cie. General Electrique. SAFT answers to CGE for all its business practices, expenditures, and product development money.

In 1948 one of the high muckity-muck Directors of CGE went to Bordeaux to visit the President (Pierre Jacquier, by name) for a friendly chat, a nice lunch, and for a fresh bottle of Beaujolais.

After lunch the Director of CGE produced a cigarette and a cigarette lighter and lit his cigarette. The President of SAFT was startled to see that there was no flame involved with the lighting of the cigarette. He assumed that it was one of those catalytic Platinum/Alcohol jobs. It was not.

The Director of CGE waved the lighter in front of the President of SAFT and taunted him with the fact that it was an "Electric" cigarette lighter with a Lead Acid Battery made by VARTA (a German battery manufacturer). He took the lighter ("Zippo" sized), removed the top and exposed the battery down in the metal holder, the cell was enclosed in a polyethylene cell container. There was some moderately nasty repartee concerning SAFT's inability to keep up with the times, etc,.

This moderate nastiness galvanized Mssr Jacquier into action. The President of SAFT called in his best model makers, technicians and engineers. He removed the offending Lead Acid battery from the lighter and told them to make a cell, from the sintered Nickel Plates of the German Engineer. The cell must fit in the Lighter to replace the offending Lead Acid Battery. The cell was to be assembled into a welded steel cell container, charged and ready to placed into the lighter.

At SAFT, when Mssr l'President has spoken, he has spoken. Even if he has spoken softly, those within hearing, hear it very loud, indeed. After a flurry of dizzying activity, and a very short time, the lighter was returned to the Director of CGE, with the new sintered plate Nickel Cadmium cell assembled. The offending Lead Acid battery was put aside.

The lighter was tried out and found to be in working order. After touring the factory and some casual talk with other members of the staff, the Director went back to Paris.

About a month (or so) later the Director was back in Bordeaux and during the course of a very nice lunch and bottle of wine he complained that the Nickel Cadmium battery in his cigarette lighter was not as

good as the old Lead Acid battery. It didn't give as many "lights per charge" as the Lead Acid battery.

The President called in his merry men (again) and asked if they had any of the original plate assemblies left over from the last time the Director was in Bordeaux. He was given a couple of dozen, or so. He handed them back to the waiting Technicians and Engineers. He told them that they were to put twice as much electrical capacity into the same cell size as the original. He sent them off to a new "Mission Impossible".

You can imagine the arm waving and cursing once they were out of earshot of the President. How the heck do you get 20 pounds of Oatmeal in a 10 lb bag?

The Solution to this enigma came by a piece of luck. One of the Technicians took two of the offending plate assemblies (complete with the separator inserted) and placed them (one on top of the other) in a very large hydraulic press. He squeezed them down with enormous pressure, to one half their original thickness (remember that the nickel particles in the sinter were very porous and that not all the interstices were totally filled with active material). The sintered Nickel particle were also very ductile, so that most of the sintered bonds were not broken. He then put these squashed down plate assemblies into a metal cell container with electrolyte (Potassium Hydroxide) and welded the thing up. These cells did not accept much electrolyte as the plates were very dense, because of the squeezing. The cell was equipped with a little rubber safety vent on the top of the cell, just in case.

All told, he made about 15 of these squashed down cells. The other technicians were typically French, and ridiculed what he was doing. When the cells were subjected to cursory testing, 11 of the cell were electrically ok (not shorted out). There were several that were short circuited by particles between the plates penetrating the separator. Some of the plate material had crumbled during the squeezing and lodged between the plates.

Over the objection of some of the other technicians, these cells were given to the President. After all, they didn't have anything else. One of these cells was inserted in the Director's cigarette lighter. It worked.

Later in the afternoon the Director left to go back to Paris, and civilization as he knew it.

The President tossed the balance of the cells into the back of the top drawer of his desk and promptly forgot about them. About two months later the Director of CGE was there again and conversation drifted to the electric cigarette lighter. The director said that the new battery was working fine, but there was one thing that was odd about the little cigarette lighter battery, it never needed water.

The President (of SAFT) was very competent about battery technology and to say that he was stunned by this revelation, would be an understatement. He never let on (to the Director) that something had been said that really set the hairs up on the back of his neck.

Later, he dug out the spare squashed cells from his desk drawer, called in the Technicians and set them to work testing the little beauties. It was found that the internal pressure (at the end of charge) did not exceed 20 or 25 psig. Later it was learned that the cells never produced hydrogen during charge. Instead, the oxygen that was formed at the Positive Plate migrated to the Negative plate (across the very thin porous separator) and the oxygen with part of the OH radical (from the electrolyte) partially discharged the Negative Plate. The active material of the Negative Plate, at the end of charge, contains quite a bit of finely divided metallic Cadmium. The reaction was assisted by the limited amount of electrolyte in the cells, allowing a typical three phase reaction to take place. This partial discharge prevented the Negative Plate from producing hydrogen as the Negative plates never came up to full charge.

If the cell doesn't produce hydrogen, along with the oxygen (produced at the Positive Plates), it doesn't consume water (the ultimate source of the hydrogen and oxygen) and so the cell can be maintenance free and sealed up.

These 10 or 12 cells represented the World's supply of Sealed Nickel Cadmium Sintered Plate Cells.

Many experiments later, SAFT established some parameters that would allow replication of these "accidental" cells. The plates were thinned down, more porous separators were found, the proper amount of electrolyte/water was established that produced the right degree of "dryness/wetness" to allow the re-combination of the hydrogen to take place.

Because SAFT knew how to make flat plates, the first commercial products for these sintered Nickel Cadmium cells were Batteries for Miner's Lamps and Railway Signal Lanterns. The cells were in the 4 to 9 ampere hour capacity range. The sealed batteries were much appreciated by the miners who were using leaky cells with construction that resembled the old Edison (Tubular Plate) battery with lots of "free" electrolyte. This free electrolyte could leak out and eat up everything in sight, including the Miner's pants and rear end.

Environmental Factors

A whole new industry was about to be born in late 1948. In 1996, the manufacture of this battery system is now a pollution target for rampant ecologists. Manufacture of the Nickel Cadmium Battery is about to go down the toilet, here in the USA. The manufacturing process to produce Nickel Cadmium Cells is difficult to keep ecologically clean, especially when examining the receding mirage target given by the Courts and EPA for acceptable levels of Cadmium pollution. There is one other thing about these Sealed Nickel Cadmium Cells. They appeared fully developed in the 50's at an energy level of about 14 watt hours per pound. This is about the same energy level as common Lead Acid cells. Other than minor improvements in capacity these sealed Nickel Cadmium Cells are still about the same as they were in way back in the very beginning. It is now more than 40 years since the commercial introduction. The "One Order Of Magnitude" improvement levels every ten years, typical to the integrated electronics industry, has never materialized with this cell system.

The thin plate Nickel Cadmium system offered very good performance at extremely high rates of discharge and good performance at low temperatures but lagged far behind the Silver-Zinc system for capacity per pound and volume.

Other electro-chemical energy systems are now slowly walking uphill away from the energy levels of the Nickel Cadmium system. The Nickel Cadmium system stands there and watches the improving capacity of other systems go bye-bye and seems powerless to effect a significant improvement. The highly touted "Metal Hydride" system appears to offer substantially higher capacity per cube per weight. The ultimate cycle life of the Metal Hydride system is somewhat suspect as current marketing statements have quite a bit of Snake Oil in them.

Dr. Carson (GE Labs, Schenectady back in the 50's) determined that the ultimate energy retrieval from Nickel Cadmium cells could be about 85–90 watt hours per pound. This has never been achieved as a manufacturing possibility, or even in the laboratory.

After almost fifty years of intense research the Sealed Nickel Cadmium cells have improved to about 16 watt hours per pound, and still have the same inherent problems seen in the first cells. When are the cells charged? The easiest answer is, "When they are warm to the touch while they are still on charge."

What's Wrong with Them

"How can I measure the "State of Charge?" You can't. There are a lot of people who have promoted a lot of devices that purport to indicate the state of charge, all have come to naught. If you really want to know the state of charge, discharge the battery and measure the energy you get out of the blasted thing.

"Why do my cells fade away and poop out?" There are a whole raft of answers for this one. The length of the explanation would make all of us old. "Why can't I make a battery of more than 6 volts that will be reliable?" Even six volts is a lot for the typical sealed cell battery. There is always one weak sister in the pack that winds up being reverse charged at the end of the battery discharge. There is no way to recombine the Hydrogen generated when the cell is reverse charged, ergo the cell dries out a little each time the battery is discharged. More volts in a battery equals more cells being driven into the reverse charge mode at the end of battery discharge.

I can only offer this friendly advice concerning the use of Sealed Nickel Cadmium Cells:

- Charge them when they are dead.
- Discharge them however you want.
- Throw them in the recycling bin when they are really dead. Don't foul the world with indiscriminate disposal of these things.

World wide manufacturers make about 200,000,000 of these cells per year, I hope they don't get in the rivers and streams.

Look forward to accusations and condemnation of the performance and pollution from the so called "metal hydride" cell. Sooner or later some company is really going to make a commercial product in metal hydride cells. When that happens, someone will certainly find something objectionable about this new and highly touted cell system. The metal hydride cell is not a panacea for the ills of the Nickel Cadmium, or the sealed battery business, in general.

As Paul Harvey has said, "Now you know the rest of the story about the discovery of the Sealed Nickel Cadmium Cell."

Access

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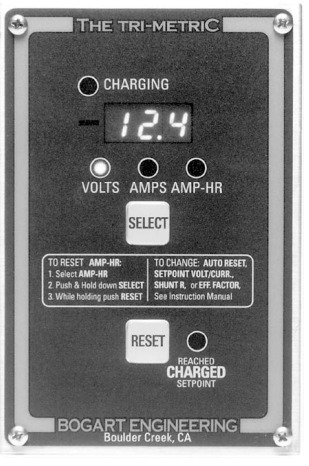

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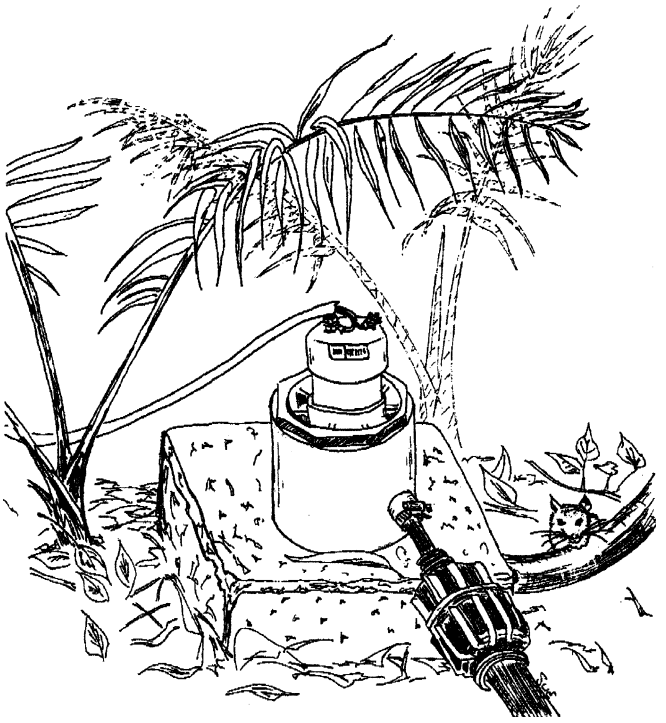
Living With "Lil Otto"

or micro-hydro in seasonally wet climates

Hugh Spencer



We recently purchased a "Lil Otto" micro-hydro system from Bob-O Schultze (Electron Connection) in northern California to provide us with auxiliary power during the wet season. It is probably the only "Lil Otto" in Australia!

Why Micro-hydro?

We operate a research station in the costal tropical rainforest of far-north Queensland (in the Daintree region). Here we have no grid power and a monsoon driven "wet" season which lasts from January to May, when the sky can be continually grey and the rain comes down in buckets (average rainfall is 4000 mm (163 inches), 3000 mm of which falls during the wet).

Our home doubles as an eating area and office for the Cape Tribulation Tropical Research Station, operated by the Australian Tropical Research Foundation. Behind it is a 30 m (100 foot) high gully with a stream that only flows during the wet. At the top is a small permanent spring which provides our drinking water. During the wet, this gully fairly cascades with water...

Getting Started

We ran a 160 m length of 1 1/2 inch black polyethylene irrigation pipe up to a small wooden dam across the gully head. This is held in place by some convenient boulders and a large cluster fig tree, obviating the need for cement which is anathema in a World Heritage area such as this. The dam is lined with several layers of black polythene to control leaks through the boulder layer that comprises the soil of the area. Several loose layers of galvanised 1/4 inch mesh function as an efficient trash filter around the pipe entrance, which is itself protected by a closed tube of the same material.

The pipe snakes its way down the gully to end at the house. We didn't read Bob-O's recommendation to use white PVC piping (it has far lower friction) and paint it, until too late. At least we have an intact run of irrigation pipe to use elsewhere should we move (if the white-tailed rats don't eat it first!). These enormous native rats have a penchant for poly-pipe, especially pipe smaller than 1 1/2 inch which gets perforated in short order.

At the house we have a control gate valve purely to turn the water off to unblock or change jets. From this a further 2 m length of pipe is connected to a modified compression fitting (Fig. 1), into which the short length of PVC pipe supplied with "Lil Otto" and which carries the jet, is a jam-fit. This makes unblocking the jet a quick process. The modifications to the compression fitting are tapers cut inside the nipples of the fitting with a lathe to create smooth conical transitions from the 1 1/2 inch to the 3/4 inch jet pipe. This eliminates turbulence caused by the square edges of the pipes which can cause considerable energy losses.

Since the present installation will probably be a temporary one, we did not want to make a permanent cement pad and drain for "Lil Otto". We devised a cement block containing a wash chamber and drain, into which "Lil Otto" wedged nicely (Fig. 2), eliminating the need for any clamps. It also keeps the unit stable

and secure against the hydro line. We modelled the "pipe-bowl" like cavity out of polystyrene foam in a box and poured cement over it. The foam was removed by digging it out and finally burning it out with a gas torch.

Subsequently, we have added a pressure gauge, salvaged from an old piece of scientific gear and conveniently calibrated in Kg/cm^2—which means that we have to convert to kilo-pascals or psi to make readings understandable to everyone else in the non-Imperial world (1 Kg/cm^2=14 psi). It reads to 3.0 Kg/cm^2, which just happens to nicely encompass the pressure range of our system (2.7 Kg/cm^2). The pressure gauge is installed just upstream of the shut-off valve. The pressure gauge greatly assists in choosing the right jet size for the flow or observing that the water flow is lessening, as a fall in pressure indicates that the jet is too large for the available flow.

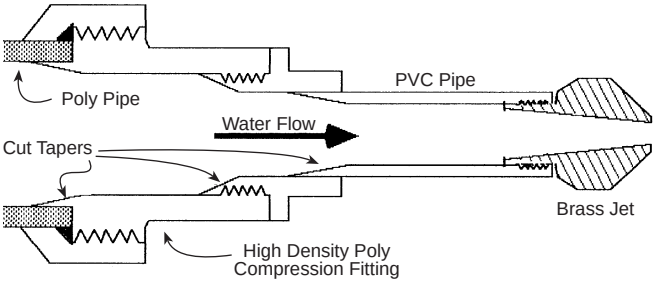


Figure 1. Cross section of the poly pipe adapter, showing where tapers have been cut with a lathe to eliminate turbulence forming steps in the interior of the pipe.

How it works

With our 30 m (100 foot) head, we get 30 Watts from "Lil Otto" using the biggest jet provided (1/4 inch diam., 36 litres/min. or 9.5 US gal./min.) and we haven't really tried to calculate the system efficiency, as there is more energy available than we can actually use. I do not use any special voltage regulator. The 12 V hydro wiring is in parallel with the solar panels, and the home-made shunt regulator deals with both. You certainly would not want to use a series regulator or a pulse modulated regulator with a DC hydro system such as this, unless you like replacing generator bearings.

"Lil Otto" is a vertical shaft micro-hydro using a very ordinary permanent magnet DC motor as the generator. It uses an injection moulded plastic impeller and the entire device is fitted in a housing made out of high density PVC plumbing fittings 12 inches high and 7 inches diameter at the base. It has an integral ammeter with a very useful 6A range. With its two power connection screws coming out the top like stubby antennas, the whole unit looks like a little white Darlek. I

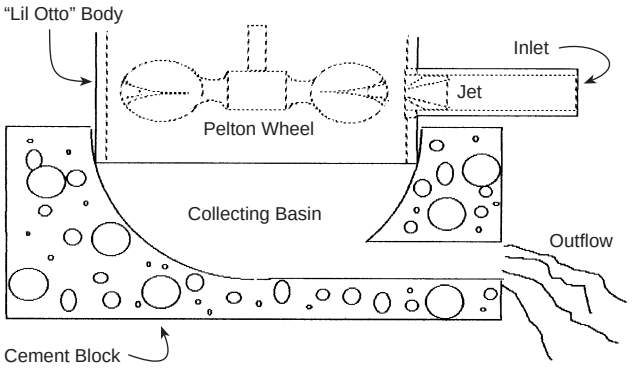


Figure 2. Cross section of the cement block with the collecting basin and drain outflow. "Lil Otto" wedges into the sides of the basin, and is held firmly in place.

put a yoghurt bucket over it to keep the top dry. A short length of 3/4 inch PVC pipe fits into a collar glued (rather weakly, in ours) to the body of the hydro to hold and align the jet with the Pelton wheel. With our cement base, I found that it was more convenient to use the (now detached) plastic sleeve as a locator in the hole on the side of the unit and rely on the heavy hydro-line and the concrete block to hold the alignment. In fact you can "tune" the power output by slightly rotating the body in relation to the jet. This arrangement allows one to readily change the jet (as the water flow changes) or to clean it. Bob-O kindly provided me with a collection of brass jets of different sizes for our trials.

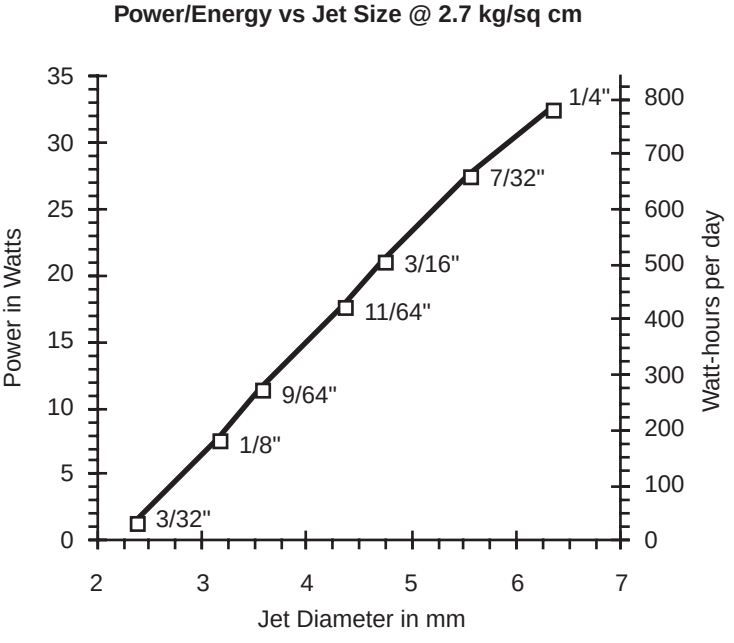


Figure 3. Power (Watts) versus jet diameter for a 2.7 kg/cm^2 pressure (dynamic) head (38 psi, approx. 100 feet height). The relationship is linear.

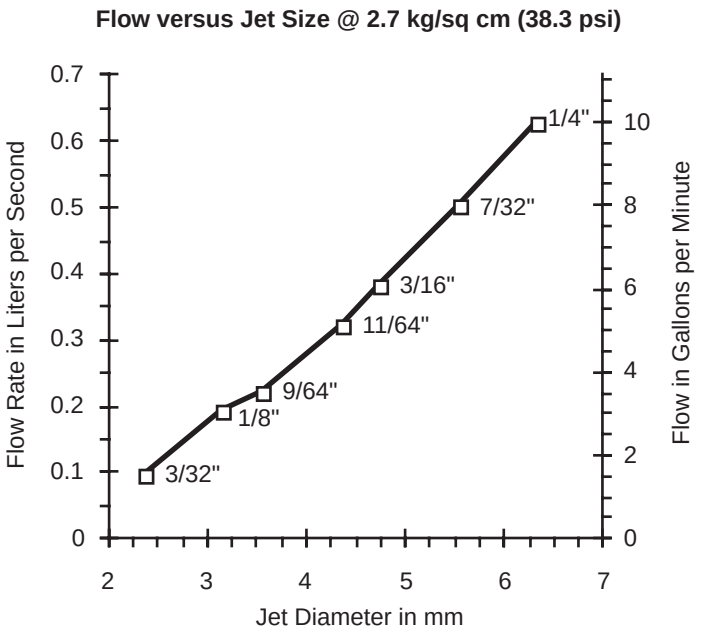


Figure 4. Flow rate in litres/sec versus jet size at 2.7 kg/cm2. This hydro is designed for low flows—less than 1 litre/sec. The performance of larger jet sizes can easily be estimated from these curves.

We love "Lil Otto"

Unlike equivalent Australian micro-hydro systems that I have looked at, "Lil Otto" is cheap ($A600), small, relatively efficient, and uncomplicated. What "Lil Otto" clearly demonstrates is that using seasonal micro-hydro resources, even in Australia, should not be sneered at. This is especially true in high conservation areas such as Daintree World Heritage area where a viable alternative to grid power must be found quickly if the area is to be properly protected. Last year (pre "Lil Otto") our batteries were quite flat by the middle of May because there was little sun (we have 400 Ampere-hours at 12 V). Over the last three months "Lil Otto" has produced about 65 kWh. As I write this (on my hydro-powered Power-Book 100) the batteries are equalizing—that is, sitting at +14 V—and gassing happily for the first time in months. It is bucketing rain, and we have oodles of light during this very grey and overcast time—the glory of it! Use of the highest strength magnets in the DC generator could greatly boost generation efficiency at little extra cost. Brush wear is minimal, and the brushes take half an hour to change. During the dry season our 100 Watts of PV panels suffice. Our total outlay, "Lil Otto", pipe, valves and fittings was about $A1,200, about the same as two 50W panels and bits, but as Bob-O(tto) Schultze says, "the sun ain't gotta shine!"

Access

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Dr. Hugh Spencer is the Scientific Director, and with his wife Brigitta, the founder of the Cape Tribulation Tropical Research Station, the only research facility in the Australian wet tropical lowland rainforests. When not playing with alternative energy, he works with the local giant flying foxes or fruit bats, or develops radio-tracking technology.

An earlier version of this article appeared in the Australian alternatives technology magazine, *Soft Technology*, #53, 1995.

Solar Drinking Water Pasteurization for the Developing World

Dale Andreatta

Between 1992 and 1994, Derek Yegian, Lloyd Connelly, and I, as graduate students in mechanical engineering at Berkeley, developed several devices for solar pasteurization of drinking water in the developing world. This is an area where simple solar technology can solve a great human need.

Introduction

According to UNICEF statistics, millions of people die each year in the developing world from water-borne diseases. If a water source is unsafe, the most common recommendation is to boil the water, but this is rarely done due to the time and scarce fuel it would require.

Contrary to what many people believe, it is not necessary to boil water to make it safe. It is also not necessary to distill water, unless the water is chemically contaminated or brackish. Heating water to 149˚ F (65˚ C) for 6 minutes, or to a higher temperature for a shorter time, will kill all germs, viruses, and parasites. This process is called pasteurization. The fact that water only needs to be heated to 149˚ F reduces the amount of energy needed and puts the required temperature into the range that can be achieved in a simple solar collector. Pasteurization is not the only technique that can purify water, and the selection of the right system should be based on local conditions. Pasteurization is particularly useful if very little money is available and only a small amount of water is needed. For example, drinking water for a family. It is also necessary to educate people about the need for clean water and how to keep their water from being recontaminated.

Basic Methods of Solar Water Pasteurization—Solar Cookers

A simple method of pasteurization is to put blackened containers of water in a solar box cooker, an insulated box made of wood, cardboard, plastic, or woven straw, and having a clear top. One popular type of solar box cooker is made of aluminized cardboard and has a solar collection area of about 23 by 19 inches. With this device, one to three gallons per day is produced in the field. Each person requires about one gallon of water per day, about half of which is for drinking and the other half for dish washing and teeth brushing. The cost for this device is about $20 US, depending on how easily available the basic materials are. Other types of solar cookers can also be used.

Regardless of the type of solar cooker used, a way of knowing that the water reached the pasteurization temperature is needed. An inexpensive device that does this was developed and is shown in Figure 1. It is a plastic tube with both ends heated, pinched, and sealed, and with a particular type of soybean fat in one end that melts at 154˚ F. The tube itself is buoyant, but is weighted with a washer so it sinks to the bottom (coolest) part of the water. The fat is in the high end of the tube. If the fat is found in the low end of the tube at any time after immersion, the water reached the proper temperature, even though it may have since cooled down. A nylon string makes it easy to take the tube out without recontaminating the water. The tube is reused by flipping it over and sliding the string through the other way. This device works in any size water container, costs about $3 and is available from Solar Cookers International. This device also works with fuel-heated water. Since heating the water to the pasteurization temperature rather than the boiling point

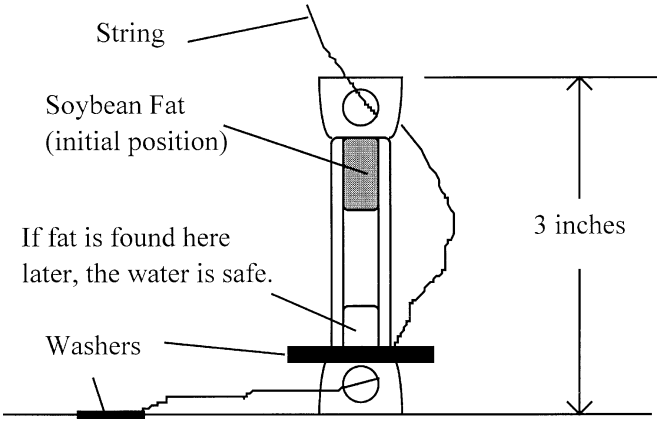

Figure 1. Water pasteurization indicator. The indicator would sit at the bottom of a water container.

reduces the energy required by at least 50%, the fuel savings offered by this simple device alone is considerable.

Flow-Through Pasteurization Devices

In the early 90's PAX World Service produced a flow-through pasteurizer made of 50 feet of black-painted tubing coiled within the same solar box cooker previously mentioned. One end of this tubing is connected to a thermostatic valve and the other to a storage tank for untreated water, which also contains a sand/gravel/charcoal filter. The small amount of water within the tubing allows rapid heating of the water to the valve's opening temperature. The thermostatic valve opens, allowing the pasteurized water to drain out of the tubing and into a second storage vessel for treated water. As the treated water drains from the solar box cooker, contaminated water from the storage tank automatically refills the tubing. Once this cool water reaches the valve, the valve shuts and the pasteurization process begins anew. This type of unit can adapt to variable solar conditions which takes the guesswork out of filling jugs in a batch process. This is also an automatic process, freeing time for other chores.

In field trials by PAX World Service and the Pakistan Council of Appropriate Technology, the device produced 4 to 6 gallons per day. The cost of this device is about $50 US.

Although this is a respectable increase, larger improvements can be achieved by recycling the heat in the outgoing pasteurized water. Once the water has been pasteurized and released form the solar box cooker, the heat in this water can be used to preheat the incoming water. Since the temperature of the water entering the solar box cooker is higher, it takes less time and energy to finish the pasteurization process.

We built several simple devices which accomplish this preheating. In one version the hot outgoing water flows on one side of a metal plate, while on the other side incoming water flows in the opposite direction (see figure 2). Heat from the hot water is transferred to the cold water, thus preheating the incoming contaminated water. Another version uses a similar idea, but with water flowing in opposite directions on the inside and outside of a metal tube. The flat-plate version is less expensive and produces somewhat more water, but the tubular version is easier to make from purchased parts. Laboratory tests using simulated sunlight showed that the flat plate unit allows around 75 to 80% of the energy to be recycled, and four to five times more water to be pasteurized over a flow-through unit without a heat exchanger. This corresponds to about 20 to 24 gallons

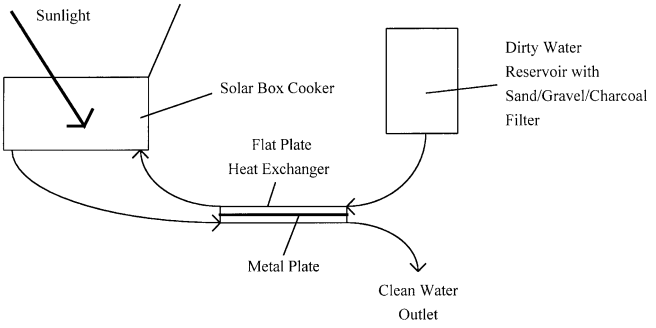

Figure 2. Flow-through pasteurization device with flat plate heat exchanger.

of treated water per day. The cost of the heat exchanger itself is about $15 US, making the cost of the complete system about $65. For a cost increase of about 30% the heat exchanger provides a roughly 400% increase in water output.

The Solar Puddle–A Low-Cost Large-Area Device

While many factors determine the usefulness of a water pasteurizer, an important figure of merit is the amount of water delivered per unit cost. We developed a device made only of low cost materials, which we call a "solar puddle." One form of the solar puddle is shown in figure 3, though many variations are possible.

The test device was a family-size unit, about 3 1/2 by 3 1/2 feet, but the puddle could be made larger or smaller. If the puddle is made larger there is more water to pasteurize, but also proportionately more sunshine collected. We dug a shallow pit about 4 inches deep, and put in 2 inches of solid insulation. We used wadded paper, but straw, grass, leaves, or twigs could be used. This layer of insulation was made flat, except for a low spot in one corner of the puddle, which is marked "trough" in Figure 3. A layer of clear plastic and a layer of black plastic went over the insulation with the edges of the plastic extending up and out of the pit. Two layers were used in case one developed a small leak. We used inexpensive polyethylene, though UV stabilized plastic would last longer. We put in some water and flattened the insulation so the water depth was even to within about 1/2 inch throughout the puddle, except in the 1 inch deeper trough. More water was added until the average depth was 1 to 3 inches depending on how much sunshine was expected. A pasteurization indicator went in the trough since this was where the coolest water collects. At this point a drain siphon was installed in the lowest part of the trough so that the most water could be siphoned out before the siphon started to draw air. The end of the siphon was held solidly in place by several small rocks. A layer of clear plastic went over the water to prevent evaporation, again with the edges extending beyond the edges of

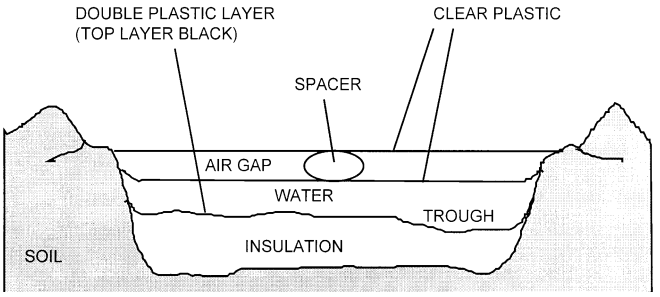

Figure 3. A basic solar puddle. Horizontal dimensions are shown compressed for clarity.

the pit. An insulating air gap was formed by putting a spacer (a large wad of paper) on top of the third layer of plastic and then another clear layer of plastic with at least 2 inches of air between the top 2 plastic layers. Finally, dirt or rocks were piled on the edges of the plastic sheets to hold them down. Once the puddle is built it is used by adding water each day, either by folding back the top 2 layers of plastic in one corner and adding water by bucket, or by using a fill siphon. The fill siphon is NOT the same siphon that is used to drain the puddle, as the fill siphon is recontaminated each day, while the drain siphon MUST REMAIN CLEAN. Once in place the drain siphon is left for the life of the puddle.

The only expensive materials used to make the puddle are a pasteurization indicator ($3), a siphon tube (about $1), and 4 sheets of plastic (about $2 for the size tested). Many tests were done in the spring and summer of 1994 in Berkeley, California. On days with steady sunshine the required temperature was achieved even with 17 gallons of water, corresponding to a depth of 2 1/2 inches. With thinner water layers, temperatures as high as 178˚ F were reached.

The solar puddle will work under conditions that are not ideal. Small holes in the top layers aren't a problem, the device works in wind or if the bottom insulation is damp, and condensation inside the top layer is not a problem. The water temperature is uniform throughout the puddle to within 2˚ F. The puddle does not work well on cloudy days. After some months, the top plastic layers weaken under the combined effects of sun and heat and have to be replaced.

There are many variations of the solar puddle. The least expensive form is built into the ground, but a puddle could be built with wooden sides on top of the ground, on a tabletop, or on a roof. We've been able to put the top layer of plastic into a tent-like arrangement that sheds rain. Adding another layer of plastic creates another insulating layer of air and makes the device work even better, though this adds to the cost. As mentioned, the device can cover a larger or smaller area if more or less water is desired. One could help solve the problem of recontamination by putting drinking cups into the solar puddle and pasteurizing them along with the water.

Access

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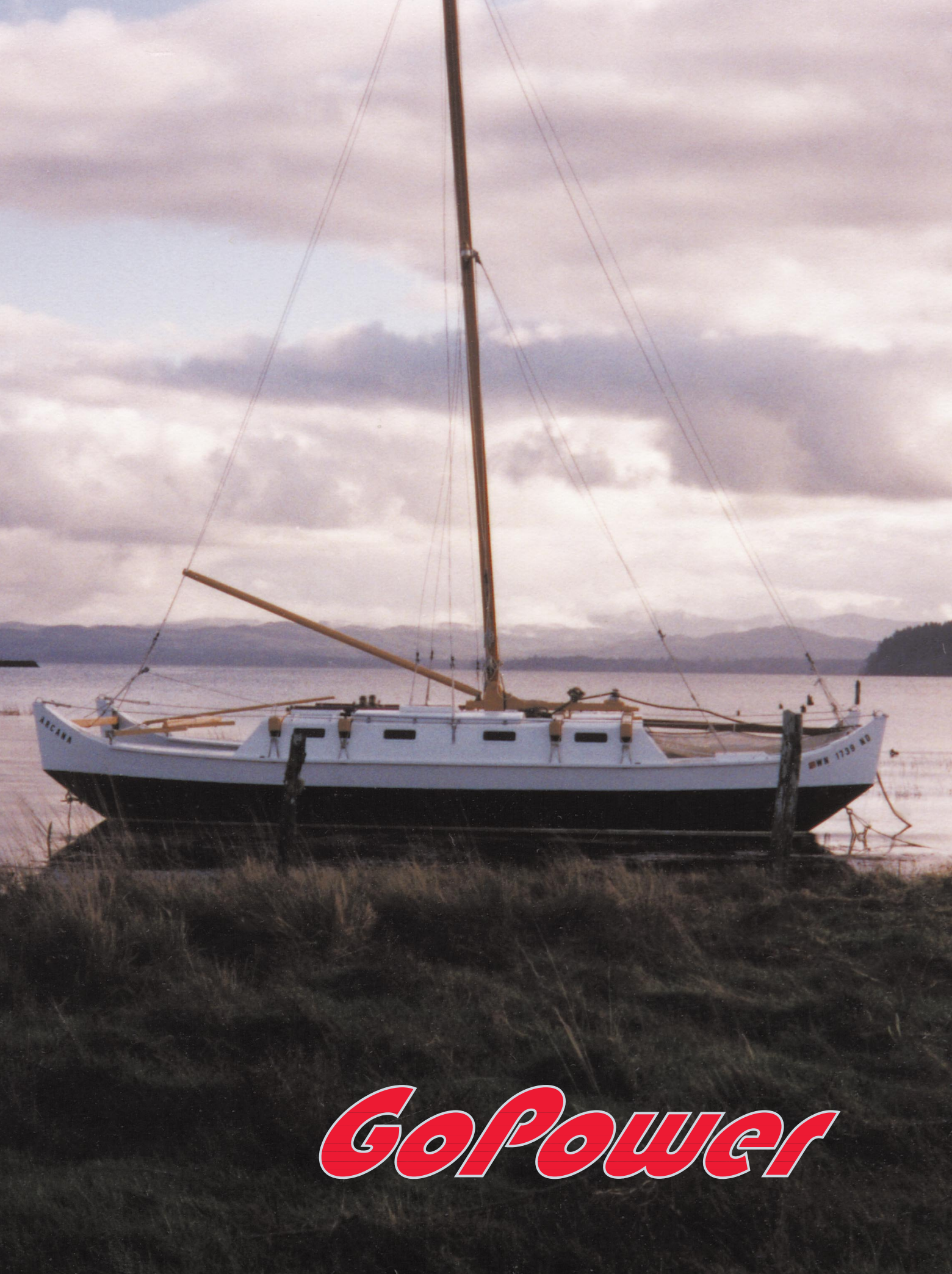
ARCANA
GoPower

Getting Around

Michael Hackleman

Got a letter from my older son a few weeks ago. Brett's excited about finishing his senior year, getting into college, and putting together some kind of electric vehicle.

This creates somewhat of a dilemma for me. After twenty years of working with EVs and two years of work on an EV book, I feel resistant to encouraging my son to get a car, electric or not. Years ago, there was a popular booklet, *50 Easy Things You Can Do to Save the Planet*. Someone is working on a booklet (sorry, I can't remember who) entitled *50 Hard Things You Can Do to Save the Planet*. Number one on this list was: Bury Your Car. That's the way I feel.

Naturals. A windmachine. An antelope.

At the same time, I understand the importance of mobility. Bicycles are not well suited to winter climes. Mind you, I know many people who use them year-round. I admire their spunk! However, if they're candid, they'll tell you the real issue is the mix of bicycles and cars. To be safe on a bicycle in foul weather equates to "being seen." Of course, there are buses, shuttles, lightrail, and carpools. Unfortunately, our the unrelenting focus on automobiles in this USA has left other forms of transportation essentially without the same subsidies, infrastructure, distribution, access, and convenience of use. What's a person to do?

A new phrase in the EV world is the NEV, or neighborhood electric car. (A similar platform is the station car.) That's what I'd like to see Brett driving. Something that works for the street (45 mph tops), is crashworthy, all weather—and affordable, too.

First car?

Brett's letter reminds me of one possible application for EVs: the high school graduation present. Think about it, parents! If a teenager is to be given a car, why not an EV? There are several benefits. First, parents don't have to worry about their son or daughter zooming off to distant cities every weekend, and maybe letting college studies slide. After all, until the infrastructure is further developed for EVs, there is the question of range! No easy fillup to go another 300-400 miles!

A second (and, perhaps, more important) issue is how one drives. A teenager may lead-foot an EV (pun intended) as easily as a gas-powered vehicle but—in the EV it will adversely affect the range. Electric propulsion has a way of teaching the driver, young or old, that if you want to go the distance, you've got to back off on jackrabbit starts and high speeds. Every EV driver has learned this. I believe the planet, as a whole, could benefit from this experience.

Serenity is where you find it!

I'm an old wind power man (some people say I'm full of it). Solar panels are cool, yet dull. Windmachines are always doing something, acting as a weather vane in gentle winds, and mesmerizing to onlookers when working. Mary McCann (Zond System, Inc.) recently sent me a photo I figured I'd share with HP readers. Wonder what the antelope makes of the whirlygig? Serenity is where you find it.

This issue of GoPower

This issue's GoPower cover is a shot of Larry Warnberg's homebuilt coastal cruiser, *Arcana*. In *Finding My Way Around*, Larry Warnberg describes the experience of living with solar and human-power and using local waterways when distant places call. Larry's work with *Arcana* reminds me of Pete and Mike

Stevenson Project's SolExplorer is solar and electric!

Stevenson's *SolExplorer.* (Since I'm working on that writeup in *The New Electric Vehicles*, I'll include a photo here.)

Also in GoPower is Shari Prange's *Electric Conversion: A Car is Born*. Chuck Hursch decided to convert a car to electric propulsion, with some help from Preston McCoy and inspiration from a longtime EV user, Scott Cornell. (Scott's Karman Ghia proves the value of treating your homebuilt EV to a nice paint job!)

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***Home Power* and the Solar Electric Light Fund (SELF) are joining forces to bring solar electricity to South Africa.**

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Small PV systems can bring light and electricity to a home for only $500. While families can't pay this up front, they can pay over several years if given credit. Rural families already pay ten dollars a month for kerosene and dry cell batteries. SELF, a non-profit charitable organization, has been providing rural credit for solar energy in Africa and Asia since 1990. But without seed funds to help communities purchase their first solar home systems, we can't provide SELF-help.

We are asking *Home Power* readers to start a **Solar Seed Fund.** SELF will provide all the overhead, including training and installation.Contributions from *HP* readers will purchase PV systems that families will pay for over 3 years. Income from installment payments will be recycled by a community-based revolving credit fund to provide loans for more systems. **Help bring Power to the People!**

Contribution Levels

- ❑ $10
- ❑ $50
- ❑ $100
- ❑ $500 (buys one home system for one family—donor will receive photograph of family with PV installation.)

Any amount accepted. All tax-deductible.

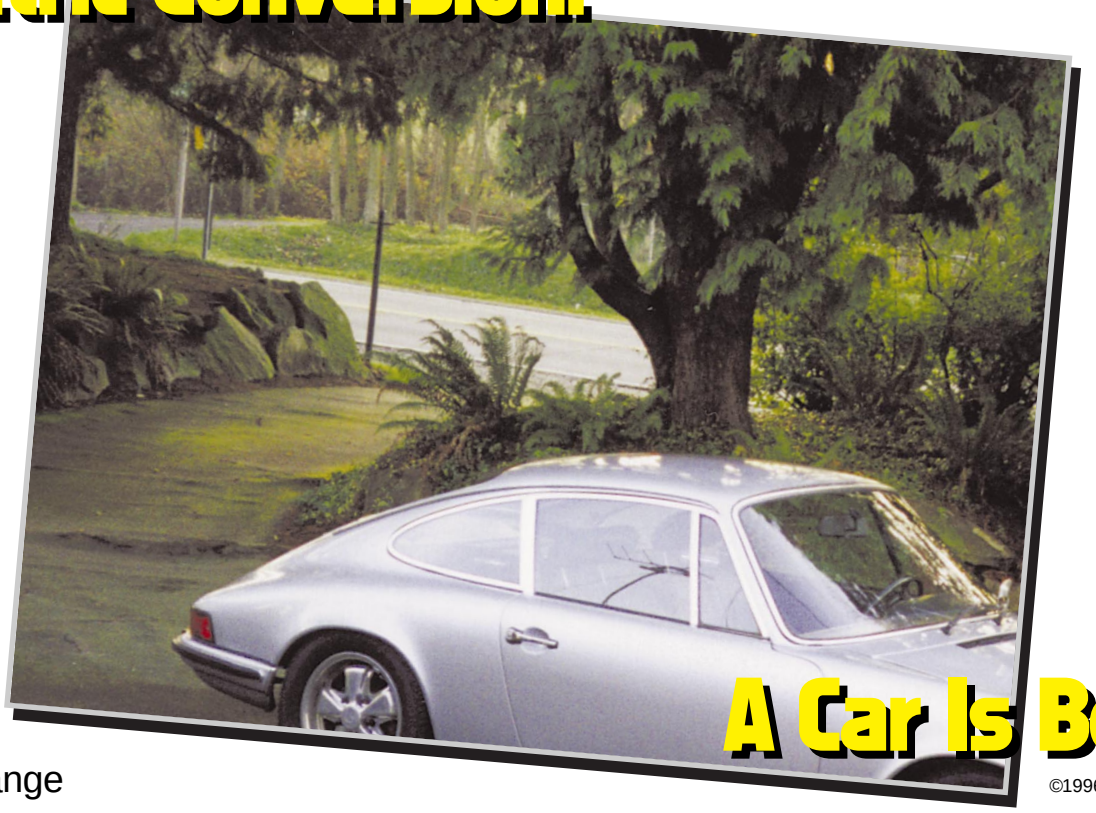
Send contributions to:

Solar Electric Light Fund
1734 20th Street, NW
Washington, DC 20009

Info: 202-234-7265 *Fax:* 202-328-9512
Internet: solarectric@self.org

Now that they have political independence, we can help lead South Africans to ENERGY independence.

Electric Conversion:



A Car Is Born

Shari Prange

It was the moment of truth for Chuck Hursch. He had worked his way through the myriad of preliminary decisions: Can an electric car work for me? Do I want to build it or buy it? Which car do I want? And a hundred similar questions. Now he had the car, the kit, the workspace and tools. It was time to move past the point of no return.

Wise Counsel

Chuck's mentors and moral support system were Preston McCoy and Scott Cornell. Both were experienced EV hands who had already built a couple electric conversions each, and were officers of local Electric Auto Association chapters. Preston was also supplying the workspace and some of the tools for the project.

The supervisor for the project was Preston's cat, aptly named Sparky. Sparky took his job seriously throughout the conversion. He was especially interested in the batteries, and spent much of his time experimenting with battery warming, using his furry self as a heater.

Preston estimated the conversion would take four to six weeks, working evenings and weekends. Chuck thought it would be closer to ten or twelve weeks, which turned out to be fairly accurate. "Preston and I have different work styles," said Chuck. "He wants to just get in and do it. I like to work slower, to think it through more and be sure I understand each step."

Out With The Old

Preston was primarily in charge of stripping the internal combustion system out of the donor diesel Rabbit. Off came the hood for easy access. Out came the engine and transmission, fuel system, cooling system, and exhaust system.

Below: This much of the donor went to the junkyard.

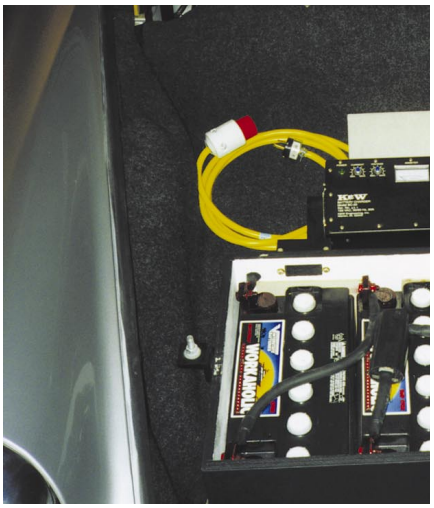
Above: The scariest part for Chuck was cutting a big hole for the rear battery box.

Preston used a beam across the ceiling to hoist out the engine, which is not a recommended practice. In this case, Preston had a really substantial ceiling beam. In most garages you would risk structural damage and personal injury if you tried that. Renting or borrowing a professional engine hoist is the preferred technique.

After stripping it, Chuck wanted to clean the engine bay ready for its new life as a clean electric car. He considered doing it by hand, but that seemed like more work than he wanted to do. Instead, he towed the car to a place that did steam cleaning.

The next part was the scariest part for Chuck: cutting holes in the chassis. There were several places that required small holes to be drilled or cut in order to mount components—and one really big hole. The rear battery rack of the Voltsrabbit kit was designed to fit down into the chassis in the hatch area behind the rear seat for safety reasons. This required removing the spare tire and cutting a large rectangular hole in the sheet metal with a jigsaw, which Chuck called “the high speed sewing machine.”

“I was really nervous,” said Chuck. “This was radical surgery. I thought, ‘If I screw this up, I could ruin this car and have to start over.’” It was hot work, since the open garage door let the sun shine on Chuck’s back, and cutting took a good part of an afternoon. Chuck proved to be a capable surgeon, and the patient came through just fine. This part of the job would have gone faster and easier with a reciprocating saw.



Left: Shop foreman Sparky closely supervised the entire conversion.

Right: Chuck installs the adapter on the motor, following the instruction manual on the bench.

In With The New

With the cutting done, it was time to start installing electric components into the car. The first was the motor. It was mated to the transmission with an adaptor plate and hub. It was easier to do this on a workbench, and install the motor and transmission into the car as a unit.

The Volkswagen shop manual gives instructions for removing and reinstalling engines and transmissions from below, but that isn’t easy if you don’t have an overhead lift for the car. For Chuck, the engine and transmission came out through the top, and the electric motor and transmission went back in from below. Most people install from the top with an engine hoist, also called a “cherry picker.”

Below: The engine bay was shiny and clean after being steam cleaned.

Above: Preston works under the car, bolting the motor and transmission into place.

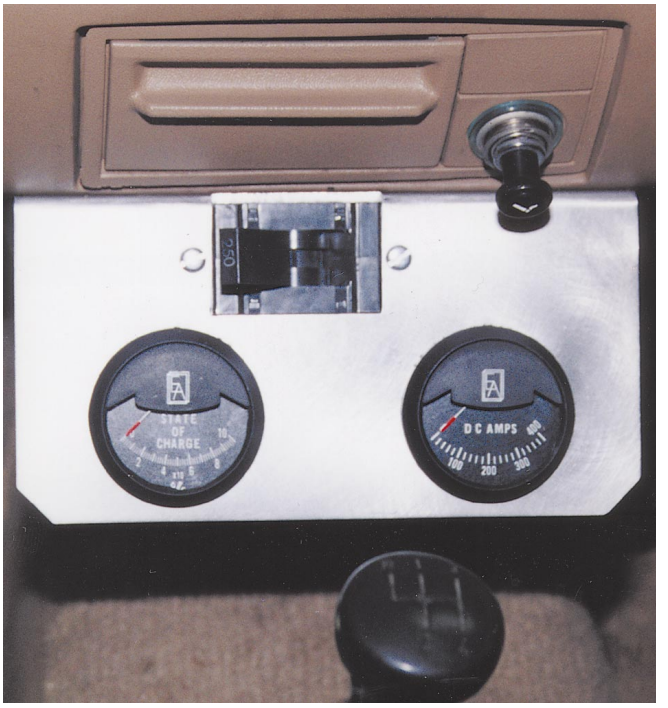
A Snug Fit

After the motor was in place it was time to install the battery racks. The rear rack fit nicely into the hole prepared for it. The front rack, which sat on top of the motor, was a more complex installation. It required hammering a portion of the passenger side firewall out of the way. The rack went in and out several times to check fit. It was a little tricky to maneuver, since it barely fit in the hood opening.

Trying his luck as an acrobat, Preston attempted to lower and fit the rack into place while pushing on the cowl with his foot. The cowl obligingly began to bend. Bad idea, try again.

On the last fit, Chuck and Preston discovered they had been a bit too enthusiastic about hammering the firewall. There was now a gap between it and the rack at the point where the rack bolted on. Oops! A spacer plate was fabricated and the project moved on.

The next step was installing the fore and aft cables under the car to connect the two battery packs. These were installed inside a length of flexible PVC hose to



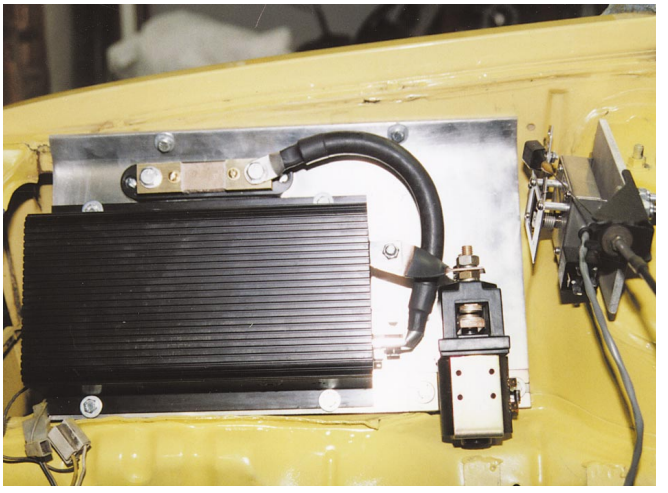
Above: The guages and circuit breaker shared a common mount on the lower edge of the dash.

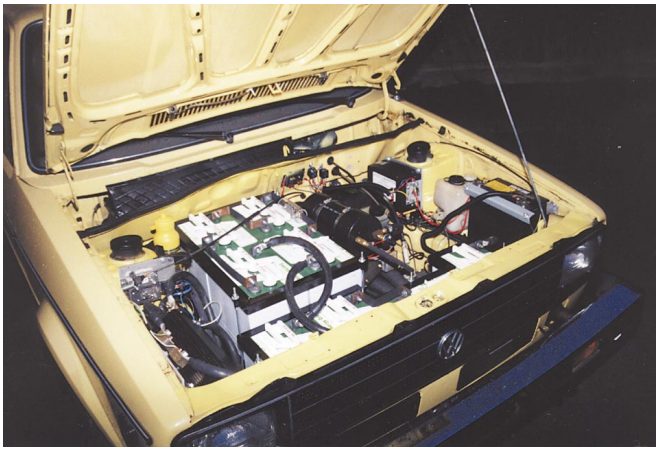
give them protection from road hazards. The 2/0 cable is thick. “It was a bit of a struggle to get it through the holes in the firewall,” said Chuck. “It was a tight fit.” This is a place where spray silicone lubricant could help.

Everything In Its Place

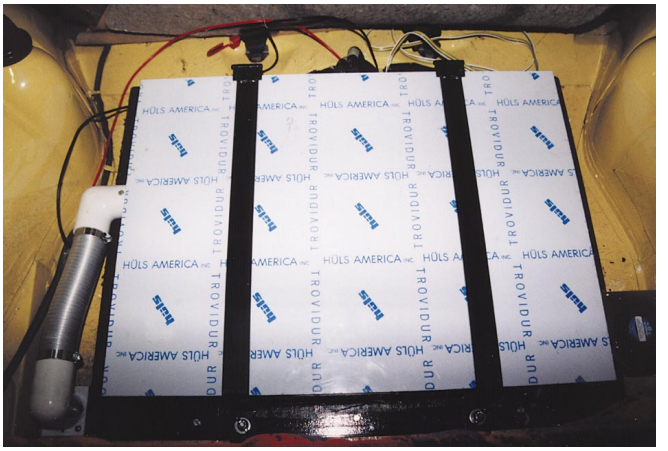
After that, the work got easier as the other components were installed. The controller, main contactor, and shunt were all installed on a common aluminum component plate, which doubled as the heatsink for the controller. They were mounted on the plate at the workbench, then installed in the car as a unit.

Below: The controller, main contactor, and shunt were installed as a unit on an aluminum plate.





Above: The former diesel engine bay is now clean and full of batteries



Above: The rear battery box fits into a rack sunk low in the chassis, strapped into place, and ventilated.

The potbox for the throttle control was mounted on the passenger side shock tower and connected to the original throttle cable. The DC/DC converter to charge the auxiliary battery was mounted on the driver's side shock tower using a bracket that had held a coolant reservoir in its previous life.

In order to fit in the front batteries, it was necessary to trim the original accessory battery mount, and replace the stock 12 Volt battery with a smaller model.

Necessity Is The Mother Of Improvisation

The controller component plate also interfered with the rectangular headlight on the passenger side. Normally, this is solved by a special headlight mount/grill block that comes with the Voltsrabbit kit. However, Chuck's Rabbit was an oddball transition model from 1980—not exactly an early style or a late style. "It's the story of my life," said Chuck. "It seems any time I buy something, it's non-standard in some way."

Chuck found that he could cut away a small part of the headlight bucket and solve the problem. He modified the grill block from the kit to close off the open area between the headlights to improve the aerodynamics.

The gauges and circuit breaker were mounted inside the car in the lower center dash area. This was a little different from normal on Chuck's car, too, but was easily accommodated.

Final Touches

The charger was mounted in the driver's side rear fender. The wiring ran across to the old gas fill on the passenger side, and ended in a male receptacle to accept the external charging cord.

With the components in place, the last of the wiring could be wrapped up. "The low voltage wiring was the easy part," said Chuck. "I just followed the instruction manual. I could probably crimp connections in my sleep now."

Chuck added one component not included in his kit, a Russco heater. This runs off the battery pack, and heats coolant in the car's original heater core behind the dash. All the car's original vents and blowers function normally. "Heat isn't really important here in northern California," Chuck said, "but I wanted it for the defrost to clear the windows in the winter and take the chill off."

The Hardest Part Was Last

The last part of the conversion was almost the showstopper: installing the charging station at home. When Chuck had moved to his apartment in 1992, he was thinking of getting a CNG car. He made a point of getting a covered carport, since he didn't want the car baking in the sun. Now he had to get permission from the management to install a charging outlet.

The initial response was very negative. "I like where I live," Chuck said. "There's a green belt, and I can walk to work. I didn't want to move. I started to investigate public charging stations as an option. There were only a couple in the area, and not close enough to do me any good. I decided to keep working on the apartment manager."

It took three proposals before he got an approval. He started negotiations in April. The first proposal called for wiring from his patio on the first floor above the cars to run through conduit to a reserved parking space. He and the manager and owner went back and forth a few times over a period of weeks. The final version stipulated fully enclosed wiring and a locked outlet.

Chuck got estimates from three contractors, and settled on one for about $500, then turned in his final proposal to the manager for approval. By June he still had no answer, but decided to build the car anyway. By the

Preston (left) and Chuck (right) toast the newly-born Voltsrabbit.

time the car was finished four months later, he still didn't have an answer. He was charging the car at Preston's house while he waited for approval. He started to really push on the manager, and wrote a letter. Finally, he got the okay. One week later, he had a charging outlet.

Satisfaction

Overall, Chuck enjoyed the conversion experience, and learned a lot from it. "I really looked forward to going to work on it in the evenings and on weekends," he said. "It was basically pretty easy. I just followed the manual as closely as possible, step by step."

Most important, he ended up with a vehicle he feels good about. It meets his driving needs without depending on fossil fuels.

Next issue we'll look at Chuck's experiences living with his electric car.

Access

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Finding My Way Around

Larry Warnberg

Above: *Arcana* means sacred vessels containing ancient knowledge.

Riding a bike or walking to school or work has been my preference since childhood. As a 47-year old kid, I still enjoy travelling under my own power, avoiding the use of autos.

Doing More with Less

As a graduate student in psychology at Southern Illinois University, I was fortunate to hear Buckminster Fuller, who was a visiting professor there in the early 70's. Bucky said there can be enough for everyone when we reduce waste through better design. So, I was inspired to reduce waste in my personal transportation. I converted my Volkswagen van to propane, drove less, rode a bike more. Gradually, I realized how much cars waste lives, diminish air and water quality, and contribute to debilitating psychological alienation and physical deterioration. Electric vehicles avoid some pollution and may be a step toward sustainable transportation. But sitting in an EV in a traffic jam seems little better than a fuming stall in a petro-hog. Mostly for my own health and peace of mind, I travel when possible without cars. I haven't had a driver's license for 15 years.

Living at a Human Pace

Commuting to an office job for 3 years was enough. My interest in organic gardening led me to aquaculture research on Willapa Bay, in SW Washington. It was also an opportunity to explore transportation alternatives. Farming oysters and clams has been economically successful for me, and a good excuse to play around with boats. A trusty canoe carries oysters ashore. Restaurant and seafood shop customers are within easy biking distance. A sturdy mountain bike and trailer provide simple local transport. Just the other day, I used this setup to bring home some 4 x 8 sheets of plywood from a lumber yard two miles away.

Above: A Hale recumbant trike and home built trailer.

Left: Larry building the *Arcana* with solar power and elbow grease.

Below: The *Arcana* is designed for coastal cruising with two double bunks, one single, galley, head, and chart table. Each hull has one 18 Watt Solarex Lite and battery to power lights, depth sounder, GPS, tools and desalinator.

A kayak has been useful for visiting friends along the Bay. I use it to make longer excursions. For example, I kayak 25 miles to our county seat and have kayaked the 120 miles up the Columbia River to Portland. By design, most of my work is close to home. The PV-powered sailboat I live on is anchored adjacent to 5 acres of leased tidelands. So, it's a short commute. On an adjacent upland are my garden, rabbits and composting toilet. I get excellent water from a hand-dug well. A floating solar-heated shop/office/galley/library provides refuge from storms. The power supply for this amphibious homestead consists of four 50 Watt Kyocera panels, four marine batteries, a Trace controller, and a Trace 2kW inverter. Cost: $2,500. It has proven to be a reliable power system. Many thanks are due *Home Power* for the information and inspiration to make it all possible.

Adventure Lies Ahead

I have cycled extensively in the Northwest, pedalling a recumbent trike using leg and arm cranks. Great touring vehicle! But I've lost my enthusiasm for dodging debris, breathing exhaust, and having things thrown at me along roads. So, long distance travel for me is shifting more to the waterways. This area has a long and rich history of water transport. These factors inspired the construction of my 31-foot Polynesian catamaran. Recently completed, I hope to use it in my oyster business and to cruise Northwest waters. Maybe beyond. I also look forward to visiting other estuaries to study how aquaculture is practiced elsewhere.

Meanwhile, I'm busy on the farm, doing what I can to promote sensible transportation. I like to encourage cyclists and paddlers by making available free tent sites and

access to the water. (Look behind the Nahcotta Post Office.) I offer a healthy discount for oyster customers arriving under their own power. Recently a group of local kayakers have established the Willapa Bay Water Trails as a chapter of the Washington State Water Trails Association. A guidebook of maps, access points, and trip hints should be available by April.

Ride on.

Access

Larry Warnberg, PO Box 43, Nahcotta, WA 98637

International Human Powered Vehicle Association, POB 727, Elgin, IL 60121-0727

Recumbent Cyclist International, PO Box 58755, Renton, WA 98058

James Wharram Designs (multi-hull plans) c/0 Tom Miliano, PO Box 35177, Sarasota, FL 34242-5177

Pygmy Boat Co. (kayak plans), PO Box 1529, Port Townsend, WA 98368

SeaKayaker Magazine, PO Box 17170, Seattle, WA 98107-0870

Washington Water Trails Association, 4649 Sunnyside Ave. N, Rm 305, Seattle, WA 98103-6900

What Is Electricity?

Benjamin Root

Electricity is the flow of electrons that occurs when a charged (unbalanced) molecular state moves toward a more stable (balanced) state…whatever that means.

Most of us use electricity every day without really knowing what it is or how it works. Though we may know that we don't have to cap our wall outlets to prevent electricity from spilling onto our carpet, many of us just use our electricity without asking any questions. When living with a renewable energy system, even one installed by a paid professional, the importance of understanding our electrical supply and demand becomes more important. We need to be able to read the meters that tell us how much power we're making and how much we're using. We need to conceive our system's ability to handle a given instantaneous load as well as loads over time. We need to be able to evaluate potential loads to determine their practicality. All in all, renewable energy systems require a greater level of user involvement than do "plug in—pay the bill" utility grid systems. This involvement can be extremely gratifying, even fun, as we monitor the power that we create and use. The satisfaction of limiting our energy usage and obtaining our power from clean renewable sources is intensified by our understanding of, and interaction with, the process. This involvement requires only a basic understanding of electricity and its properties.

Kinds of Electricity

Electricity is usually classified as one of three types, static, direct current (DC), or alternating current (ac). As we try to understand electricity we will move through descriptions of all three types. Starting with static electricity will help us understand direct current, which will in turn help us understand alternating current. This article is about the fundamentals of direct current electricity. With this knowledge we should be ready for the discussion of alternating current on page 73 in this issue.

Static Electricity and State of Charge

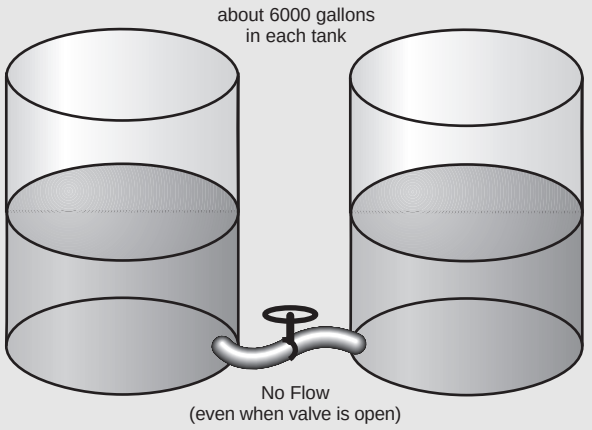
Most of us are familiar with certain forms of static electricity. Shuffling across the carpet in socks creates static electricity. We can see the effect when we touch a pussy cat's nose. Rubbing a balloon on your little brother's head creates static electricity too. We can see the effect when his hair stands on end and when the balloon sticks to the wall. In both these cases we have used friction to create a static electric charge. Another example of friction causing static electricity is lightning. The friction between clouds or between the clouds and the earth creates a powerful static charge. We see and hear the effect in the flash of lightning and the clap of thunder.

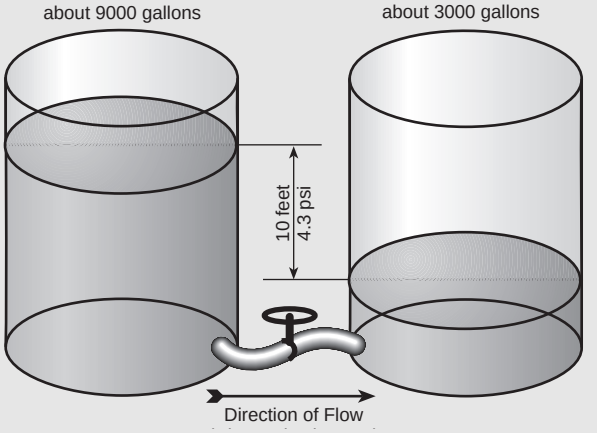
The static charge in all of these situations is based on the creation of an electrical imbalance between two objects. To understand this imbalance we must look at an atomic level. Look at the diagram of the hydrogen atom in side bar 2. This simplest of all atoms shows two of three possible components that make up any atom. In the center (nucleus) is a proton. A proton carries a positive (+) charge. The outer component is called an electron. It carries a negative (-) charge. The amount of negative charge that an electron carries is the same for any electron in any atom. The same is true for the positive charge of any proton. In the hydrogen atom shown here, the charge of the electron cancels or balances the charge of the proton creating an electrically neutral atom. The number of protons and electrons in the atoms of different elements vary. For example, the copper atom has 29 protons and 29 electrons. The number of protons and electrons in any element are normally equal. In this balanced state, the positive charge of the protons equals the negative charge of the electrons and the atom is electrically balanced.

The third component of an atom is the neutron, which resides in the nucleus with the proton. As its name suggests the neutron has no charge associated with it. Therefore, while it's important in defining the atom, it plays no role in electrical balance.

A charge is created when a substance loses the balance between the number of electrons and protons in its atoms. In the examples of static electricity, it was friction that stripped the electrons from one substance and left them as excess with another. A static charge can also be created through chemical reaction, as in a battery. The substance with missing electrons has a positive charge while the substance with extra electrons has a negative charge (remember that electrons have a negative charge).

Side Bar 1: Volts & Amps





Voltage

Think about two cylindrical water tanks sitting side by side. Each tank is 20 feet tall and 10 feet in diameter. Near their base, a pipe with a valve connects the two pipes. If both tanks were half full then the water level inside each tank would be the same. If we were to open the valve no water would flow through the pipe.

If we were to close the valve and then use a bucket to transfer about 3,000 gallons from one tank to the other, two things would happen. First we would be very tired. This is important because it reminds us that we did a certain amount of work in transfering that water. We could figure out how much work, but it would make you feel even more tired. Second, the water level in the two tanks would be different. The level in one tank would be about 15 feet, the other would be about 5 feet. With the valve closed the water would stay at these levels. Were the valve to be opened water would flow through the pipe as the levels try to find equilibrium, but lets wait on that.

The difference in height of the water levels in those two tanks creates a potential for work to be done. Remember, the amount of work that could be performed by allowing the water levels to equalize is equal to the amount of work initially required to create that 10 feet of difference. This is analogious to the potential between unbalanced electrical charges that is voltage. In an electrical system the imbalance is measured in numbers of electrons of difference between two terminals. In our water tank model the imbalance is measured as the vertical distance between the two water levels. The 10 feet of difference in levels creates a pressure imbalance of about 4.3 pounds per square inch. This pressure exists whether or not water is allowed to flow through the pipe. In the same way, voltage exists whether or not electrons are allowed to move through the wire.

Amperage

Current is the movement of electrons. Again, imagine our model with the two water tanks. If we open the valve between those two tanks the pressure will cause water to flow through the pipe until there is equal water levels in both tanks. Once level, there is no longer any pressure to push water through the pipe. Flow stops.

Flow between the two tanks can be measured in gallons per minute. This is a rate measurement just like the measurement of electrical current. The ampere is a rate unit equivalent to number of electrons over time.

Two things dictate the amount of flow in any system. One is pressure, or voltage in electricity. The other is friction, or resistance in electricity. In our water model the size of the pipe limits the amount of water that can be forced through it. More pressure will cause more flow, or a bigger pipe will allow more flow. Given a big enough pipe the water levels will equalize almost instantaneously. This is analogous to electricity: more voltage will cause more current, or less resistance will allow more current.

The unit of charge is defined as a coulomb (koo-lumb) named after French physicist Charles A. Coulomb who measured the forces existing between charges. A coulomb is equal to 6.25×10^{18} electrons (625 with sixteen more zeros). A coulomb of charge can be positive (+) meaning that there are 6.25×10^{18} electrons missing from the atoms of a substance. Or a coulomb of charge can be negative (-) meaning that there are that many extra electrons orbiting the atoms in a substance. How is this unit, the coulomb, useful to us? Do we need coulometers in our renewable energy system? Not really, the importance of a coulomb as a unit of charge is within the definition of two other basic electrical units—the Volt and the Ampere.

The Volt

It takes a certain amount of work to move electrons from a balanced state to an unbalanced state. Just like magnetism, similar electric charges repel each other and dissimilar charges attract each other. This attraction between the equal number of negatively charged electrons and positively charged protons holds the atom

in a balanced state. A certain amount of work is required to remove electrons from a balanced atom because of the attractive force of the equivalent protons in that atom's nucleus. Also, work is required to force a free electron to join an already balanced atom because of the repelling force with the pre-existing electrons in that atom.

Any atom prefers a state of balance. Work must be performed to create a charged atom, whether positive or negative. In the examples of static charge, work was performed in the shuffling of feet, rubbing of balloons, and in the blowing about of clouds.

Once a charge has been created, the potential exists for work to be done. This is because a charge wants to equalize. The attractive and repulsive forces try to move electrons to a position where they are in balance with protons. A charge is capable of giving back the same amount of work as was required to create it in the first place.

The "volt," named after Alessandro Volta (1754-1827), is a unit of potential work per coulomb of charge. One volt equals one joule (a metric unit of work equal to 0.7376 foot pounds) per one coulomb of charge. Think of a volt as the amount of desire that a charge has to become balanced. It is the force that the unbalanced electrons exert in an attempt to move back to a balanced state.

So far we have been defining charge as it occurs on a single substance. For charge to be measurable and useful, we must actually compare the charges of two substances. It is the difference of charge between two points that is the useable imbalance. Remember shuffling our feet across the carpet? It is meaningless to say that our bodies carry a charge unless we compare it to the charge of the carpet, or the charge of the cat's nose. When we measure voltage we are measuring the potential for work to be done were we to let those two unlike charges balance each other. This potential is described as a force or push towards equalization that exists between two charges. It is the difference between the two that is the key. If a terminal has 1 coulomb of extra electrons (-1C) and another terminal has 1 coulomb of electrons missing (+1C), then the total difference of charge is 2 coulombs. If one terminal has 3 coulombs of extra electrons (-3C) and another terminal has 1 coulomb of extra electrons (-1C) the difference of charge is again 2 coulomb. Even though both terminals have a negative charge, it is the difference that creates the potential for work to be done. Voltage between the two terminals exists.

Voltage is a measure of the electrical push available from the the difference in charge between two points. It's the quantity of force that is created by the imbalanced electron's desire to move to a balanced state.

The Amp

So far we have been defining electricity as an imbalance of charge. We've talked about coulombs and volts and how they define the state of a charge as well as its potential for doing work. All of these descriptions fall under the category of static electricity. Static means, by definition, at rest, without change, or showing no movement. Static electricity is not really doing anything. It is merely the potential to do something. Static electricity really won't get any work done.

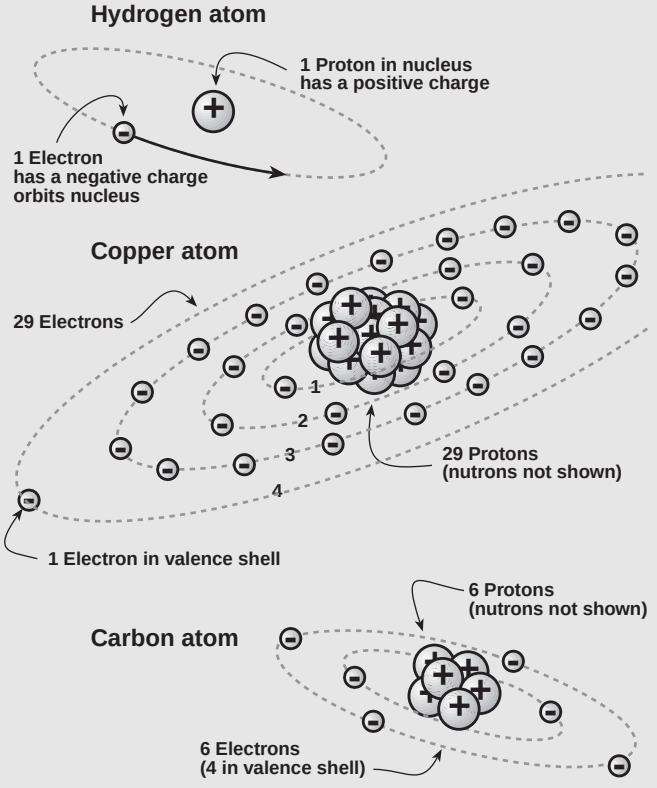
"Wait," you say, "What about shocking the poor kitty? It sure looked like something happened!" You are right, something did happen, but it wasn't static electricity. When we shuffle across the carpet we create an imbalance of charge between us and the carpet. The movement of electrons to create this imbalance is actually direct current electricity. Now, as we stand there in front of unsuspecting kitty, there is static (potential) electricity due to the imbalance of charge between our finger and kitty's nose. We could even measure the voltage between us and kitty. In theory we could stand there all day and voltage would stay the same, and kitty wouldn't care. There are many ways that a static charge will dissipate itself over time but lets ignore them for now; it's kitty that we are concerned with. As we reach out toward kitty, and kitty curiously stretches its nose up to meet us, thing are about to change rapidly! When we are close enough to kitty to allow the electrons to move, they do! Remember voltage, the forces pushing and pulling electrons toward a state of equilibrium. These electrons move through the air, like a little bolt of lightning, just as they would move through a copper wire. The important thing is that those electrons are moving, in this case from you (-) to kitty (+). Electrons continue to move until the charges between you and kitty are balanced (or at least until the difference in charge is of insufficient voltage to continue to push electrons through the air. See the side bar discussion of resistance and conductance). This movement of electricity is called current, just like the movement of water in a stream. The electrons move in only one direction, from a place of more negative charge to a place of less negative (or positive) charge. This unidirectional flow of electrons is called direct current.

We have a unit for measuring current called the "Ampere" named after Andre M. Ampere (1775-1836). One amp is defined as the movement of one coulomb (remember 6.25×10^{18} electrons) past a point in one second. When we measured voltage we measured the

Side Bar 2: Resistance & Conductivity

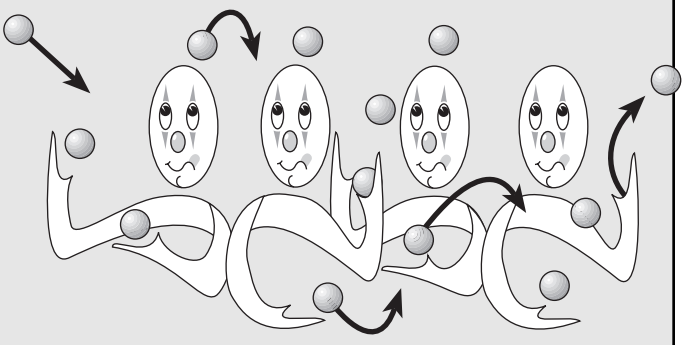
Electricity is the movement of electrons. Conductivity and its inverse, resistance, is the measurement of how easily electrons move through a substance. The amount of energy that must be introduced to knock an electron free from an electrically balanced atom varies with different elements. What is the difference between elements that causes different levels of conductivity?

As we look at a model of the copper atom we notice that there are 29 electrons orbiting the nucleus. It is the nature of electrons that they orbit the nucleus in layers or shells. Each shell can hold a certain number of electrons. However, the maximum number of electrons that can be in the farthest shell out from the nucleus is eight. This outermost shell is called the valence shell and the number of electrons in that shell is called the valence number.



An atom with a full outer shell is electrically stable (valence number of 0). These elements are the inert gasses like helium and neon. Also, compounds can be composed in such a way that their atoms share electrons and simulate full valence shells. Examples are rubber and glass. In these cases, the electrons are more tightly bound to the nucleus. The substance resists the transfer of electrons from atom to atom. It is a poor conductor.

On the other hand, atoms like copper have only one electron in their outer shells (valence number of +1). Because this outermost single electron has a weak bond to its nucleus it is more easily confused about which nucleus it is actually orbiting. It can easily be moved from copper atom to copper atom by the electromotive force (voltage). The repelling force of an excess of other electrons behind it combine with the attractive force of extra protons in front of it make it skip from atom to atom. The metals gold and silver also have one electron in their valence shells. They are good conductors too.



Imagine this: A line of lazy guys standing side by side. Each holds one ball in each hand. If we throw a ball to the guy on the end he has to start juggling to handle that third ball. But he is a lazy guy. Sure, he could pass that ball to the next guy in line, but heck that guy is lazy too. Basically it gets to be a hastle to get these guys to pass balls down the line.

Now imagine a line of jugglers standing side by side. Each is already juggling three balls. Each juggler always has one ball in the air at any given moment because that's what juggling is. If we throw a ball to the juggler on the end it is easy for him to ignore his one ball in the air and accept this new ball. Now the next juggler has to deal with four balls but he can also easily let his one ball in the air drift to his neighbor. This transfer happens easily because balls in the air are easily displaced by the extra ball coming in from one side. It is also easy for this displaced ball to then displace the ball on the other side. Balls move down the line!

Each juggler represents an atom and each ball represents an electron. In the atoms of good conductors there is that one electron in the valence shell that acts as the "ball in the air".

Elements that don't conduct as well as the metals, yet aren't really insulators, are appropriatly called semiconductors. Carbon, silicon, and germanium all have four electrons in their valence shells. They are as willing to gain electrons as they are to give them up. This makes the semiconductors useful in transistors and other applications dependent on minute electrical relationships.

Element	Symbol	Atomic #	Valence#	Catagory
Silver	Ag	47	+1	Conductors
Copper	Cu	29	+1	
Gold	Au	79	+1	
Aluminum	Al	13	+3	
Iron	Fe	26	+2	
Carbon	C	6	+4	Semiconductors
Silicon	Si	14	+4	
Germanium	Ge	32	+4	
Hydrogen	H	1	+1	Active Gasses
Oxygen	O	8	+6	
Helium	He	2	0	Inert Gasses
Neon	Ne	10	0	

difference in charge between two points or terminals. To measure amperage, we are actually measuring the rate at which electrons are moving. We must provide a path along which the electrons can move. This completed (or closed) path is called a circuit. To count how many electrons go by in one second we must put our meter right in the circuit, that is, in the middle of the flow.

The amp is a rate of electron flow and contains the element of time, in this case, seconds. You may also have heard of the unit amp-hour. Contrary to the sound of the name, amp-hour does not contain the element of time. Rather, it is a quantity of electrons. One amp-hour is equal to 3,600 coulombs of electrons, (3,600 seconds in an one hour).

Resistance and Conductance

You may be beginning to recognize that there is a relationship between volts and amps. It makes sense that the amount of voltage, or push, affects the amount of amperage, or flow. There is one more element of an electrical system that affects the relationship between voltage and amperage. Resistance is opposition to electron movement. It is what voltage must push against in order for current to flow. Resistance is usually concentrated in the loads of an electrical system. This is where the movement of electrons is converted into work. This work may be the creation of heat, light, motion, or whatever task we are trying to accomplish with electricity.

The unit of resistance is called the "ohm" named after Georg Simon Ohm (1787-1854), and is symbolized by the Greek letter omega, "Ω". One amp moving through one ohm of resistance for one second will develop one joule of heat. Don't worry about this formula. The important thing is that the units which define ohms are the same ones which define volts and amps: number of electrons (coulombs), time (seconds), and work (joules).

All substances have some amount of resistance. Copper wire has very low resistance, about 0.001Ω for a 1 foot length of 10 gauge copper wire. This is why copper wire is chosen as a good way to move electricity around efficiently. The filament in a standard incandescent light bulb has a much higher resistance. It's the relatively high resistance of the filament that causes light, and heat, to be generated. Air has a very high resistance to current flow, as does rubber and glass. These things are considered to be insulators because they generally allow no current to flow. However nothing is a perfect insulator, meaning nothing has infinite resistance. Remember the flow of electrons through the air from a charged finger to an unsuspecting kitty's nose.

The opposite of resistance is conductance. Resistance is the measure of how hard it is for current to flow. Conductance is the measure of how easy it is for current to flow. The unit of conductance is the seimans (S) and is defined as S = 1/Ω. For more discussion of conductance (and resistance) see the side bar on conductance.

Ohm's Law

Remember that we discovered that there are relationships between volts, amps, and ohms because they are defined by common units. This relationship is called Ohm's Law and is one of the most useful rules for figuring out what the heck is going on in a DC electrical system. Ohm's Law says 1 volt moves 1 amp past 1 ohm, or volts = amps X ohms. You may have seen E=IR written elsewhere; It means the same thing. E stands for electromotive force, or volts; I stands for intensity, or amps; and R stands for resistance, or ohms. It may seem confusing to have symbols that differ from their corresponding units, but soon we will understand Ohm's Law so well that these discrepancies won't matter.

E(volts) = I(amps) X R(ohms)

I (amps) = E(volts) / R(ohms)

R (ohms) = E(volts) / I (amps)

Using simple algebra on Ohm's Law we can figure out any one value if we know the other two. Take a look at the cheat circle diagrams for Ohm's Law and the Power Law in the side bar. Volts, amps, and ohms are very interdependent in an electrical circuit. Lets look at how variations in one element can affect changes in the other two.

Open Circuit

An open circuit is no circuit at all. Once we begin to understand electricity we use the terms "open" and "closed" to describe the positions of a switch rather than "on" and "off." This is because what a switch does is open a hole or gap in the path of electrons so that electrons can not flow. This is what we used to call "off"; no electricity can flow to our load and no work gets done. When we close the switch we are creating a complete circuit. Electrons can then move along the path, through our load, and work gets done.

What are the values of volts, amps, and ohms in an open circuit? It's interesting to note that even when a circuit is open it has voltage. Remember that voltage is measured across the terminals of the source. Voltage is the pressure pushing those electrons. The pressure still exists even if the electrons cannot move anywhere. Let's assume, for this example, that the voltage across our source terminals is 12 Volts.

What is the resistance of this open circuit? We can assume that wires have almost no resistance. We might know the resistance of our load too. But the important factor here is that "open" part of the circuit. The "open" may be a switch that is supposed to be open, or a broken wire, or a failed connection. In any case, the resistance of that open is almost infinitely high.

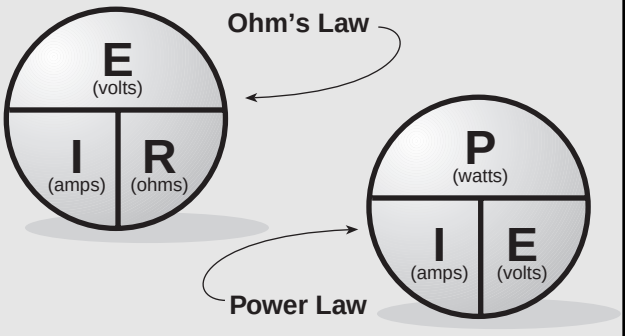
Let's use Ohm's Law to figure out how many Amps are moving in our circuit with the known values of voltage of 12V and resistance approaching infinite ohms. Amps are equal to 12 Volts divided by some incredibly huge number of ohms. Math solves the number of Amps to be effectively zero. No electrons are moving when the resistance is infinite ohms. This makes sense conceptually as well as mathematically: if there is no completed circuit for the electrons to move through, then no electrons will move. Amperage, the measure of how many electrons are moving past any point in the circuit, is zero.

Let's remember that kitty for a moment. A spark jumped the gap between our finger and its nose. This might lead us to think that current moved across an open circuit. Actually Ohm's Law can solve this paradox for us. Remember that air has high resistance, but not actually infinite resistance. If we can apply high enough voltage to overcome the resistance of a small gap of air, then we can get a current to flow. Another example of air conducting is the spark plug in a car. The ignition coil sends thousands of volts to the gap. This is enough pressure to cause electrons to flow through the air. Lightning is a very large and frightening example of high voltage forcing current through the high resistance of air. Our 12 Volt example, on the other hand, is effectively useless at forcing current through the air of an open circuit.

Short Circuit

We have looked at what happens to the amount of current, at a given voltage, when resistance is very high. Now lets look at what happens to current when resistance is very low. A short is named for a case when the electrons have found a path toward equalization that is without any significant resistance. This might be a short cut that lets electrons move without going through the desired load. It also might be a wrench dropped across two terminals of a battery. Let's look at Ohm's Law to figure out current in a case where potential is equal to 12 Volts and resistance is close to zero ohms. Current is equal to 12 Volts divided by a very small number of ohms. The math tells us that as resistance goes down amperage goes up. As resistance approaches 0 ohms current approaches infinite amps. Wow! infinite amps. This sounds serious, and it can be.

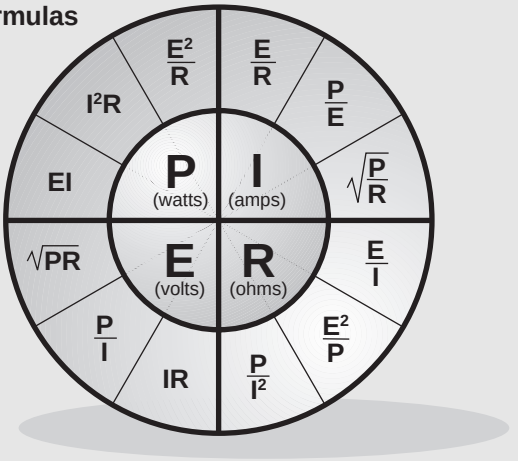
Side Bar 3: The Law



If you feel like we are using circular reasoning when defining electricity you are right. Volts, amps, ohms, and watts are interdependant. These diagrams illustrate the relationships between potential (as volts), current (as amps), resistance (as ohms), and power (as watts).

To use these figures to solve for an unknown unit merely find that unit's symbol and put your finger on it. Yes, put your finger right on the diagram. The remaining visable symbols then show the formula relationship for your known units. For example, assume you already know amounts for volts and ohms and you want to figure out amps. Put your finger on I (remember that is current) and notice that what remains is E (volts) over R (ohms). This is the same as E divided by R. If you do the math your answer will be current measured in amps. If solving for voltage (E) we see the formula I next to R. This is the same as I multiplied by R. We can use the diagram for power law in the same way to solve for relationships involving power (as watts).

All Formulas



The larger diagram at the bottom shows all possible formula for the solving of voltage, amperage, resistance (ohms), and power (watts).

Side Bar 4: Powers of Ten

(abbreviations commonly used for electrical units)

Name	Symbol	Unit Multiplier
tera	T	1,000,000,000,000 or 1.0×10^{12}
giga	G	1,000,000,000 or 1.0×10^{9}
mega	M	1,000,000 or 1.0×10^{6}
kilo	k	1000 or 1.0×10^{3}
milli	m	0.001 or 1.0×10^{-3}
micro	µ	0.000001 or 1.0×10^{-6}
nano	n	0.000000001 or 1.0×10^{-9}
pico	p	0.000000000001 or 1.0×10^{-12}

Heat is created when we push significantly more current through a wire or other conductor than it can easily handle. This excess heat can start a fire or even weld that wrench to those battery terminals.

Ohm's Law illustrates the mathematics of the short circuit situation. It should make conceptual sense as well. Without resistance to limit current flow, voltage will try to push all the unbalanced electrons back to a position of balance instantaneously. Lots of electrons moving in a fraction of a second equals a whole lot of amps!

At a constant voltage, current and resistance are inversely related. This means when resistance goes up current goes down, and when resistance goes down current goes up. Now, just to confuse things, remember that voltage can change too. Voltage and current have a linear relationship. Consider for a moment that the resistance in a circuit it held constant. As we raise the voltage the amperage goes up too. If we lower the voltage then amperage goes down. Sound confusing? Think of it this way: if we have more push (volts) against the same resistance (ohms) we will get more movement (amps).

Lets look at the Ohm's Law relationship in one last way. Imagine that we want to send a constant current through a circuit even though the resistance of our circuit is changing. We can accomplish this by raising voltage in proportion to increases in resistance and lowering voltage in proportion to decreases in resistance. The amount of current will stay constant.

Ohm's Law is the key to understanding the interrelationship between the three main variables in any electric circuit. With it we can predict the affect that a change in voltage, amperage, or resistance will create. We can also better conceptualize what electricity really is. It is not so important to understand the micro physics of why electricity happens. It is more important is to understand electricity by how it acts and what it can do.

Power Law

It would be nice if we could combine the three variables in Ohm's Law into one good unit. We can. The unit is called the watt, named after James Watt (1736-1819), and is a measurement of power. Power is an amount of work done in an amount of time. A watt is defined as the work done in one second by one volt moving one coulomb. We already know that the movement of one coulomb in one second is an amp. Therefore we can also define a watt as being equal to one volt times one amp.

P (watts) = E(volts) X I(amps)

Because of the relationship between volts and amps that we know from Ohm's Law, we can solve for power in other ways

$P(watts) = I^2(amps) \times R(ohms)$

$P(watts) = E^2(volts) / R(ohms)$

These formulas are merely variations based on combining Ohm's Law with power law. Look at the cheat circle diagrams for Ohm's Law and power law in the side bar.

Power and its unit "watt" are the basic unit for measuring electricity. Electrical professionals are often heard to say, "Watts is watts." While this may not seem very profound, or even literate, the point it makes is a good one. Power is what we need. It is why we use electricity. We want to power stuff... lights, TV's, toy trains…important stuff. To use watts as the base unit means that we can compare apples to apples in any system. In an antique 32 Volt wind powered system, a Watt is a Watt. In a 12, 24, or 48 Volt renewable powered home, a Watt is a Watt. In a 1962 VW bus with a six Volt battery, a Watt is a Watt. In a 3 Volt penlight or 120,000 volt high tension lines, a watt is a watt.

We have explored electricity from a subatomic level up through a basic unit of power. We may never find ourselves evaluating our renewable energy systems in terms of numbers of electrons or coulombs. Hopefully, a vague understanding of these concepts will create a more solid understanding of what electricity is and how it works. We will use volts, amps, ohms, and watts frequently. An understanding of what these units are, how they are derived, and how they interrelate will make electricity all the more interesting and fun. With what we now know about electricity we are ready to evaluate what is occurring in circuits of many kinds. We have a base from which we can ask intelligent

questions about more complex electrical systems, and then understand the answers. We are ready to explore the complexities of series, parallel, and combination DC circuits (look for an article in issue 53). We are also ready to explore the nuances of alternating current circuits (see page 74 in this issue). As we dig deeper into electricity in general, and renewable energy in specific, we will continuously call upon the these basic concepts, definitions, and units. This is just the beginning.

Access

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Basics of Alternating Current Electricity

Part One—Sine Waves

Richard Perez

Renewable energy systems have always been big users of direct current (DC) electricity. PV modules make DC electricity and DC electricity is what batteries store. With the advent of modern power inverters, however, more and more RE systems are using most of their power as alternating current (ac), just like everyone who lives on the grid. Understanding the basics of alternating current is simple—it's really just a matter of timing...

Changes

Direct current electricity is constant and consistent. Current flow is unidirectional. Voltage polarity is rigid—positive is positive and negative is negative and that's that. If you are not familiar with direct current electricity, then read Ben Root's article beginning on page 64 of this issue. You will need the concepts and terminology there to understand what you will read here.

When we enter the realm of alternating current (ac) everything changes. And I mean everything—voltage, current and even the concept known as resistance in DC electricity. The static world of direct current is lost in a sea of changes.

Fortunately the world of alternating current has its own consistencies. Sound confusing? Well, it can be. Alternating current electricity is constantly changing. Current flow and voltage vary by the millisecond. But these constantly changing electric manifestations follow a regular and repeating pattern. It is in the structure of this endlessly repeating pattern that ac electricity reveals its secrets. It's just a matter of waves and timing.

Waves

Alternating current is based on sinusoidal waves. These sinusoidal waveforms betray ac electricity's beginnings in rotational motion. Rotary ac alternators produce power with sine wave characteristics. Before understanding ac electricity, it is first necessary to understand the sine wave and how it behaves.

A sine wave is derived from angular motion. Imagine a circle with a rotating radius, exactly like a clock's face with only a minute hand. As the hand ticks off the time, the angle between the hand and the horizontal 9 o'clock axis changes. The height of the hand's pointer above the horizontal axis also changes. The sine of the angle at any point is the height of the point above the horizontal axis divided by the radius of the circle.

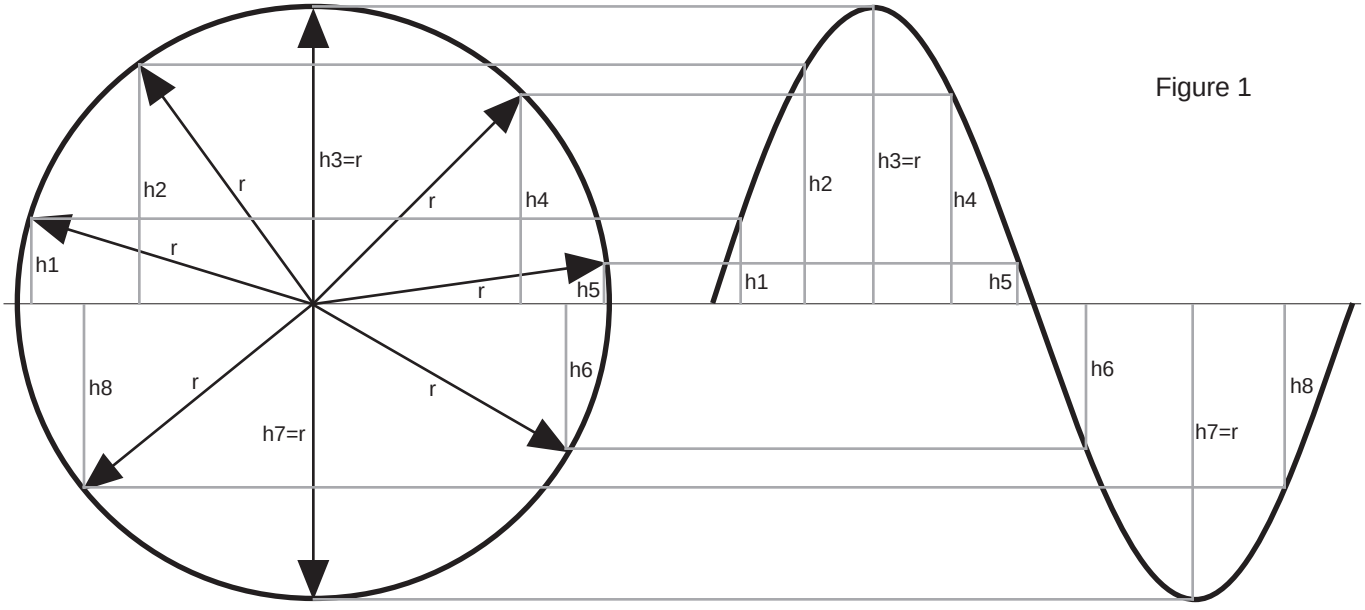

Figure 1

The left hand side of Figure 1 shows the rotational motion (like a clock face). The right hand side of this illustration shows the sine wave generated by the different values of h as the radius spins around the circle from zero to 360 degrees. There is a thin horizontal and centered line dividing both the left and right sides of the illustration. This thin line represents zero. Values above this line are considered positive while values below this line are considered negative.

Early makers of electricity used the rotary motion of water wheels and steam turbines to generate electricity. If you spin a loop of wire within a magnetic field, or conversely spin a magnetic field within a loop of wire, then electromagnetic force (EMF or voltage) is induced in the wire. This induced voltage will have a sinusoidal waveform—it will be alternating current electricity. The rotary nature of early electrical generation set the sinusoidal standard for all that was to follow.

Time and Time Again

The concept of the sine wave is familiar to anyone who stayed awake during high school math. Y=sin(x) describes a pattern that is endlessly replicated in nature as well as in alternating current electricity. Sound like mathematical mumbo-jumbo? Well, look at the sine wave shown in Figure 2. Notice a few things about this sine wave. The height of the waveform (that is, the distance from the horizontal x-axis to the curve) varies. This distance above or below the x-axis is called amplitude and it may be either positive, negative, or zero. While the amplitude varies from point to point, the pattern endlessly repeats itself. Maximum and minimum heights are always the same. The pattern has a particular wavelength and then it repeats itself over and over again. Every sine wave has a frequency. Frequency is number of times the waveform repeats itself during one second of time.

While the trigonometric equation y=sin(x) sounds like a artificial human construct, it is really our feeble attempt to understand one of nature's regular patterns. If you think this is an abstract concept just watch ocean waves, or the way a pendulum moves, or our Sun's apparent motion across the sky. Nature is into sine waves.

Standards

In the early days, before 1900, electrical pioneers realized the need of standardization of electric power. By 1900, the Battle of the Currents had been fought and won by alternating current. In the dim beginnings of commercial electricity, there was some doubt as to whether the electric power would be generated and used as direct current or as alternating current. Edison championed direct current and Westinghouse wanted an alternating current standard. Westinghouse and alternating current won out. The big reason was that alternating current could be run through transformers and have its voltage easily changed. This made long distance transmission of electric power possible.

When alternating current won out over DC, there still had to be standards set by the utilities for that current. At what voltage would it be delivered to electric power consumers? What frequency would the alternating current have? Well, in the USA, the utilities decided to deliver a sine wave voltage that varied from +164 volts to -164 volts. They decided that the frequency of this sine wave would be 60 cycles per second (60 Hz). These standards are arbitrary. In Europe for example, the voltage standard is often twice that of the USA and the frequency is 50 Hz. Figure 3 shows a graph of the American standard of ±164 volts and 60 Hz.

Figure 3 graphs the voltage of the alternating current against time. The x-axis (horizontal axis) of the graph is time and is expressed in degrees. The y-axis (vertical axis) represents voltage. Note that the voltage waveform peaks at 164 volts positive and 164 volts negative. This voltage is know as peak to peak voltage. Note that the sine wave is complete in a single 360° cycle. Since this sinusoidal waveform has a frequency

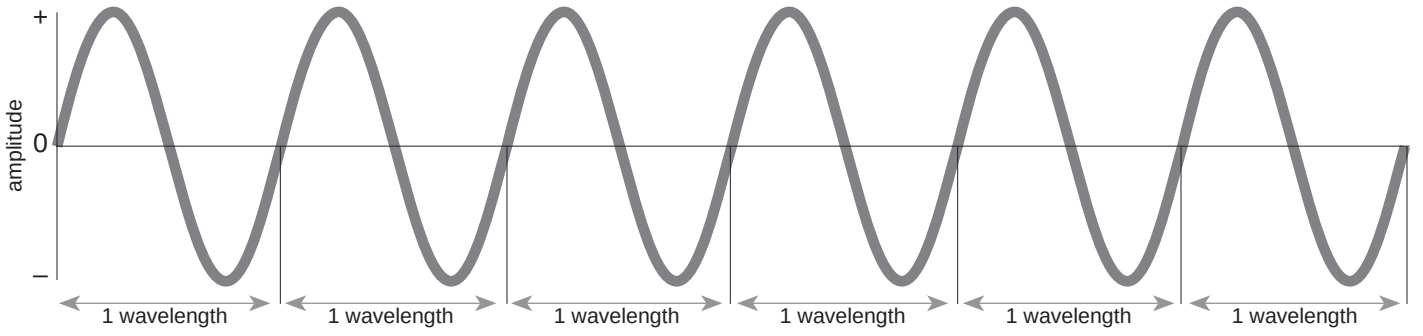

Figure 2

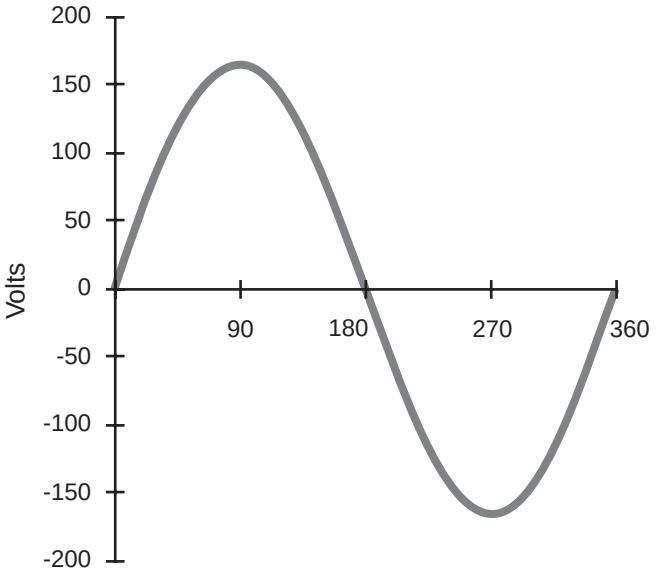

Figure 3

of 60 cycles per second, the period (or duration) of each cycle is 16.666… milliseconds (or 1 cycle divided by 60 cycles per second). To find the period (or duration) of a sine wave divide its frequency into 1.

Out of Phase and In Phase

All this sine wave stuff doesn't get complicated until we start thinking about multiple sine waves. And that's what ac electric power really is: two sine wave fronts, one of EMF (voltage) and the other of electron flow (current). What were to happen if we were to graph two sine waves of the same frequency and amplitude, but we started the second wave later than the first one. If we start the second wave 45° later than the first, then the second wave is said to lag behind the first sine wave by 45°. The second wave front is said to be out of phase with the first by -45°. This out of phase situation has tremendous relevance in ac electrical circuits and is shown in Figure 4. In the later parts of this series of articles, we will see many real world situations involving ac waveforms where voltage and current become out of phase.

We can also graph two sine waves which are in phase (i.e. they have the same frequency and start at the same time), but have different amplitudes. This graphical representation fits the following real world scenario: alternating current being fed to a lightbulb. The black curve on the graph, Figure 5, represents the voltage of the ac waveform while the gray curve represents the current flowing into the lightbulb. Note that when the voltage supplied to the lightbulb reaches a maxima or minima so does the current flowing through the lightbulb. Which makes sense from Ohm's Law. When the voltage waveform is zero (at 0, 180° and 360°, etc.), the current flowing through the bulb is also zero. Which also makes sense via Ohm's Law. While these two waveforms represent different quantities (voltage and current), they are in phase (i.e. they have the same frequency and begin and end at the same time).

Figure 5 shows us the basic landscape against which alternating current electricity operates. The voltage of the waveform changes constantly and regularly. The voltage of an alternating current waveform can be either positive, negative, or zero. The current flow in an alternating current circuit is just the same—current flow can be either positive, negative, or zero. In a direct current circuit the electrons start at the negative supply voltage and move through the circuit to the positive end of the power supply. The same is not true for alternating current. Since the polarity of the current varies, so does the direction of the current. In ac electricity, an electron does not make a complete path through the circuit, but instead merely wiggles back and forth 60 times a second. In ac electricity, there is not constant voltage or even a constant direction of electron flow.

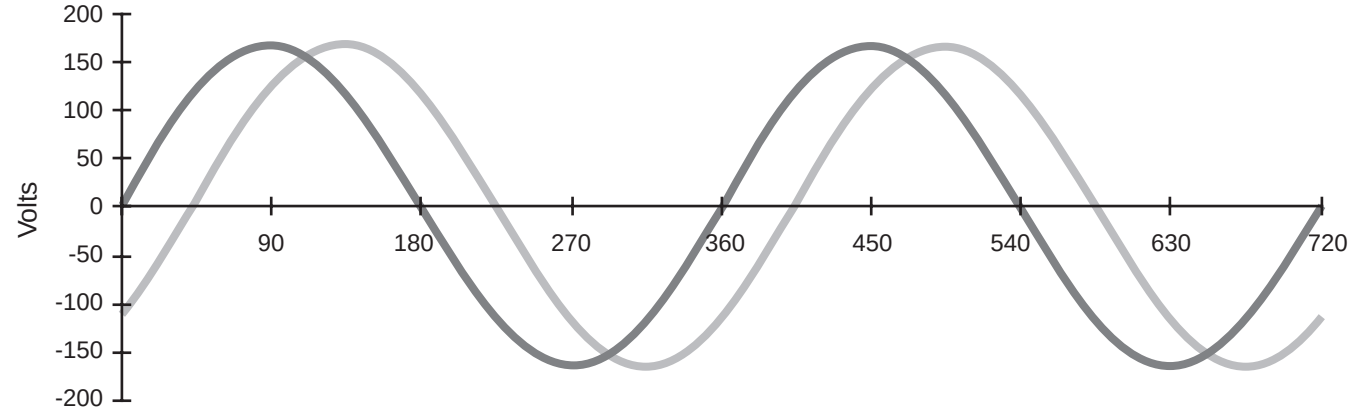

Figure 4

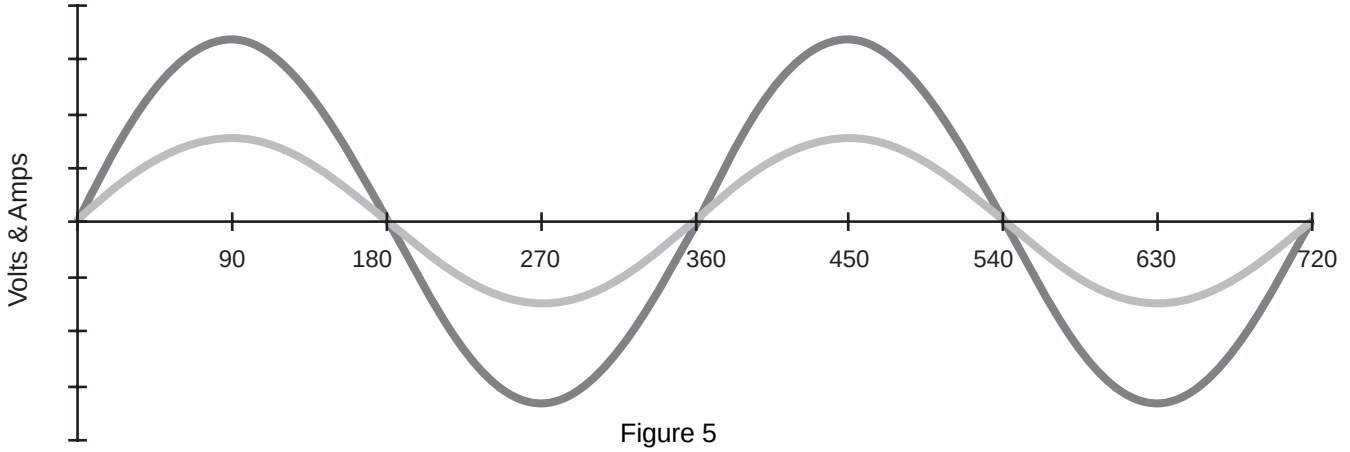

Figure 5

These concepts are slippery and a far cry from the gut-level simplicity of direct current electricity. This article is the first in a series. I just want you to get a feeling for ac electricity based on its constantly changing, but repetitive, sinusoidal nature. In the articles that will follow, we will examine what happens when ac power is fed into devices like motors, transformers, and electronic lighting. We will examine and hopefully even understand abstract, yet entirely real, concepts like how power is manifested and measured in ac circuits, what happens when voltage and current are not in phase, impedance or ac resistance, power factor, and real world trivia such as why your 2500 watt inverter won't start the 1500 watt electric motor in your well pump.

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An Account of Lead Acid Battery Restoration Using EDTA Tetrasodium

Jon Kenneke

After reading the several stories in Home Power describing how to "restore" lead-acid batteries, it was time to try it. Most lead acid batteries are disabled by a build-up of sulfur on the lead plates (sulfation). There are two methods to break sulfation: chemical (using EDTA tetrasodium), and electronic using a pulsed device that electrically breaks the bond. For this first try, chemical chelating agents are used. Refer to the article in Home Power #20 & #21 for details.

EDTA tetrasodium is a chelating compound. This means that it has the ability to break crystal bonds. In this case, it is breaking the bond between the lead and the sulfate crystals.

I collected six old lead-acid batteries as my test subjects. Two of these batteries are Exide, two are Sears Die Hard, one Les Schwab, and one Fred Meyer brand. They vary in age and usage. Five of the batteries were deep-cycle (Exide, Die Hard, Fred Meyer), and one was a standard car battery. I decided to use a car battery for comparison. After the test, four batteries came out usable.

The Exide batteries were used in a bass fishing boat to run a 24 volt trolling motor. They were used in series. One of the Sears Die Hard batteries was used in a 12 volt trolling motor. The other Die Hard was used as an electric fence charger, drained to about 60 percent before charging. The Fred Meyer battery was used in an RV. Of course, the car battery was used in a standard automotive application.

These batteries are not industrial quality units, like many renewable energy people use. But, they provide a good comparison for EDTA effectiveness. And, many folks do use "consumer" quality cells in their power systems. These batteries are cheap, and easy to get. Enough said.

The three batteries used to drive trolling motors were deeply (80 percent or more) cycled, and cycled twice every weekend during the bass fishing season. They would sit in the off season, self-discharging. Some fisherman use trickle chargers, but the sources of these batteries did not. Hardly an ideal situation. The other batteries were charged on a consistent basis.

I checked the specific gravity and voltages on all the batteries before applying EDTA tetrasodium and charging. The EDTA was obtained through Fisher Scientific, to guarantee purity. A 500 gram bottle was purchased for around 20 dollars. This bottle came factory sealed, and fully warranted to be pure. I obtained this through a local distributor. (See access section).

The specific gravities of all the batteries indicated that they needed recharging—around 1.225 (less than the ideal specific gravity of 1.260). This was a good indicator of sulfation.

As specified, 1 tablespoon of EDTA tetrasodium was added to every quart of electrolyte. The EDTA dissolved readily in distilled water. It was interesting to note that the battery cells fizzed after adding the EDTA. This was alarming. This happened in all the batteries, but did not seem to be an indicator of trouble.

It is important to avoid contact with the electrolyte in batteries. I highly recommend using rubber gloves, and eye protection. I used eye protection, but no rubber gloves. I have acid burns as proof that avoiding contact with skin is VERY important. Please take heed to my advice. This can be a very safe procedure if you are prepared. Use your brain.

After adding the EDTA, the batteries were gently shaken to thoroughly mix the EDTA with the electrolyte. This is an important step, as I have learned from previous experience. Be careful not to shake to batteries too hard and spill the acid electrolyte. Remember, acid can be neutralized with baking soda. Just make sure that none enters the battery cell.

After the EDTA was added, all the batteries were charged at the C/10 rate. The EDTA treatment works best (according to literature) if the cells are put in an equalizing charge for 8 hours. At the end of this charge, the batteries could be heard "boiling".

After the equalization charge, the batteries were put on a standard charge for 12 hours. After this, cell voltage and specific gravity were measured again.

The measured values are in the chart, below:

Battery	*Use*	*Voltage*	*SG*	*Notes*
Exide 1	Trolling	10.47	1.260	Cell cracked
Exide 2	Trolling	13.20	1.260	Great
Die Hard 1	Trolling	12.95	1.250	Pass
Die Hard 2	Elec. Fence	13.10	1.255	Good
LS Car	Automotive	13.10	1.255	Good
Fred Meyer	R.V.	13.30	1.260	Great

Exide number one developed a crack in the bottom of the case, and leaked over the floor of the garage. I did not try to revive this unit.

Note that the final voltage is not with charge voltage applied. With the charge voltage applied (using a 120 VAC charger) that measured voltage was 14+ volts on all batteries except the leaky one. This is consistent with the recommended equalization voltage.

As a true “acid” test, one of the Die Hard batteries was used for trolling on a bass fishing trip. Previously, the battery would start dying after one hour of use. After the treatment, no performance degradation could be detected until 4 hours into the trip. At this time, motor output came to a halt—a cell had shorted. To the recycle bin with this battery, and Exide number 1.

The car battery is now used for occasional lighting in the greenhouse, and is kept charged by a 20 watt photovoltaic panel. It has maintained its output voltage for a winter and summer season. The load on this battery is a 30 watt light for 10 minutes nightly. Before the EDTA treatment, the battery held no usable charge.

All the other batteries are used in a float service. This has encountered no problems, although they have not been deep load cycled. It would seem that thicker plate, industrial quality flooded lead-acid batteries would have batter results.

In summary, the EDTA restoration was quite successful in these batteries. It is safe to say that EDTA gives extra life in batteries that are not physically damaged. It will be quite interesting to compare these chemical restoration results with electrical restoration.

Access

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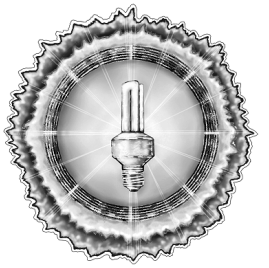
Home Power's Business



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Don Loweburg

I got a letter from an IPP member in Canada that I'd like to share with you. It begins "I have read about your struggle with the electrical utilities in California and the other US states in *Home Power*. In Canada the solar industry is beginning to experience similar problems—although perhaps on a more intrusive scale. Ontario Hydro (owned by the government) has set up a private company (Ontario Hydro Solar), they have bought a solar manufacturing company, and they are selling solar products. They are trying to put most privately owned solar companies in Ontario out of business by selling solar systems directly to the off-grid markets.

The industry in Ontario is beginning to organize but we are hampered by the long distances between the dealers, we're all small business with little spare time, and we lack expertise in lobbying.

While some items may not be duplicatable between the US and Canada we were hoping that you could supply us with materials that you have developed that would help us in our organizational efforts. Thanks for any assistance you may be able to offer and I look forward to hearing from you shortly." Signed, Rob McMonagle, Ontario Solar Providers Association (OSPA).

Familiar Story?

I read the materials he sent and several days later we had a long phone conversation. Deja vu!

The dealers and installers up there, like their counterparts here in the states, are generally one or two person companies. They put in lots of work for every sale and always provide lots of service to their customers. The utilities and bureaucrats respond to the dealer's protests with the same arguments we have listened to for years. Such as "the utilities will add credibility to your product", "this is a win-win situation", and "we will help grow your industry."

In an article in the June 15, *1995 Electrical Business*, McMonagle "estimates that there are between 300 and 400 Canadian companies involved in supplying solar energy equipment.....selling primarily to the cottage sector, and to those who live outside the areas serviced by Ontario Hydro."

The OSPA and other industry members fear that if Ontario Hydro or other provincial hydro utilities, become big players in the solar-energy market, private companies will not be able to compete for a market share, but will be squeezed out by the greater resources major utilities can expend on securing that market for themselves.

Included in the packet of material Rob sent were a couple of articles about how Ontario Power is selling portable PV systems directly to customers (over priced and under sized). Also an article describing Ontario's purchase of module manufacturing technology. Remember when SCE was going to produce PV modules using spherical cell technology in partnership with Texas Instruments? Looks like TI unloaded it on Ontario!

The good news is that the Canadian industry is organizing. In fact, the Ontario Solar Providers Association and IPP have agreed to form an alliance. Though our material assistance to one another may be limited, we are sure that the power of information and communication will be a powerful mutual asset. Canadian readers be sure to contact Rob. See the end of this article for access.

California Net Metering Update

The California utilities are still trying to throw a monkey wrench into the PV net metering law. Last issue we detailed PG&E's blatant attempt to obstruct the implementation of California's new net metering law. PG&E's proposal drew a barrage of protests. In fact, so many strongly stated protests were received that PG&E rescinded the filing. The next maneuver can only be described as insidious. Rather than re-writing

the filing, they moved the issue into another venue, their current General Rate Case (GRC). The GRC proceedings are much more formal and not as accessible to the public. Furthermore, all the letters of protest will not be carried over to the GRC. Only parties to the proceedings can make input. Becoming a party is more than the average person is most likely willing to do. And there is more. In past issues we have reported favorably on SCE's net metering policy. The administrators of SCE's PV program have told us that through some fluke, "mistake" or inadvertent miscommunication, their old (favorable) net metering policy was abolished in their just completed GRC. An IPP contractor in the field reports that customers applying for net metering are told that there is a moratorium in effect and ratcheted meters (can't go both ways) are being installed! It is our opinion that these utilities are blatantly breaking the law. Is it time we had a legal test case in California?

On the other hand, giving credit where credit is due, we applaud San Diego Gas and Electric for their net metering policy that levies no additional charges.

Growth of End User PV

Last issue we looked at some statistics pertaining to the PV industry. To recap, it has been determined that less than 10% of PV production goes to utilities while a much larger amount ends up being sold to domestic end users; remote homeowners, telecommunication companies, etc. To get another view of the PV industry, I surveyed two publications. I know this is very informal, but I thought the result interesting. The first publication I surveyed is *Solar Industry Journal* published by Solar Energy Industries Association. A few years ago the content and advertisers were primarily directed at the solar thermal field. Things have changed. In the latest issue there were 18 articles (anything from press release to full article) and 16 advertisements for PV or PV related products. Photovoltaic articles and advertisements totally dominate the publication.

Another publication I surveyed is *Mother* something. Though this magazine frequently features PV articles there were none in this one. However, PV advertisements numbered seven, a significant increase during the last couple of years. Not very scientific I admit, but the point is that PV is booming and it is the end use market that is growing.

The point is: Utilities should get out of PV. They are actually slowing its commercialization. On one hand, their PR and hype create false expectations with the public, while on the other hand, poorly designed systems and failed projects (Where do you think all those used modules are coming from?) create disappointment and generate false marketing signals. Commercialization also requires the development of a PV infrastructure, something utility projects completely fail to do.

The fact is they don't want an independent PV infrastructure. Once the public subsidy trough dries up, expect the utilities to move away from PV and tell people it's not cost effective. Just like they used to say before THEY got into the PV Biz. My goodness, we can't actually have people generating their own power! It's against the law, ain't it?

Restructuring and PV

Utility restructuring is a fact here in California, though the details are still uncertain. In general terms, restructuring will mean a move toward a competitive retail power generation market while distribution and probably transmission will remain monopoly activities. It's generally believed that eventually, this will be a national trend. One concern is that during this process the utilities will dump such things as demand side management (DSM), efficiency programs and the incorporation of renewable energy sources in the power mix. Most of these programs were mandated in one way or another and in a "competitive" environment they will end up being unfunded. There is demonstrated, very strong agreement by the public that renewables and energy efficiency are good. The question in a competitive situation is, "How do they get paid for?" What seems to be evolving is something called a renewable portfolio standard (RPS). IPP is attending workshops on this concept. The idea is that all sellers of power will be required to have a mix of renewables representing a certain percentage of the total power sold. If they are deficient, they may purchase credits from another (we assume one who has an excess). There is a great deal to be worked out yet and more will follow in the next issue.

Members Update

We keep growing! National membership now totals 139. Membership categories include professional (installers, dealers, manufacturers, distributors, and designers); users; and advocates (students, educators, and policy people). We do not distribute our list in general, although we do put together selected lists for specific purposes. One such list is available. It is our California professionals list. Containing 49 listings (over 50% contractors), this referral list covers all regions of California. Members, what do you think of our new logo? How about our business members using it in ads?

Education

Solar Energy International has classes in both stand

alone and grid connected PV. IPP strongly endorses their program. We have several IPP members who have completed the SEI program and are now in the PV business. Congratulations! Till next issue, Don

Access

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COMMUNITIES MAGAZINE

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Disasters Happen

John Wiles

Accidents happen—and, if they involve your PV system or one that you installed, they can be a disaster when you or the qualified installer is forty miles away down a muddy road.

- The daily cycling of the currents cause connections to loosen.
- Nails are driven into walls and into cables.
- Metal tools are dropped across terminals.
- Aging batteries go into thermal runaway.
- Birds and animals chew on insulation.
- Structures shift and damage hidden cables.
- Sunlight ages and hardens cable insulation.
- Well pumps lock up.
- Generators and PV arrays develop ground-faults.

This Code Corner and the next will discuss how to implement the requirements of the National Electrical Code ® (NEC ®) that will help to keep accidents and incidents like these from becoming disasters. Overcurrent protection will be covered in this column and disconnects in Home Power 53.

Definitions of Overcurrents

Overcurrents in electrical system wiring can be of two types. Overload currents are represented by sustained currents in the 2-6 times normal range caused by partial faults in the insulation of conductors and circuit overload problems like stalled pump motors. These currents can cause long-term deterioration of the cables from overheating. The overheating is generally not sufficient to cause fires initially, but may damage the cables and surrounding building materials.

When uninsulated conductors or conductors with damaged insulation come into contact (positive to negative), a short circuit occurs and currents can flow that are many times the ampacity (current-carrying capacity) of the conductors. Partially damaged insulation may allow high currents to flow even if there is not a direct, low-resistance short circuit. In most PV systems, the batteries are the source of very high currents and can deliver thousands of amps into short circuits. These high currents in short circuits create heat which can cause further system damage and fires as insulations melt and then ignite.

NEC Requirements

The National Electrical Code requires that every current-carrying conductor in an electrical power system be protected by overcurrent devices. The devices are either fuses or circuit breakers and act to interrupt the flow of current when subjected to sustained overload currents or short-circuit currents.

The overcurrent devices are normally located in the circuit in the ungrounded conductor nearest the source of the potential overcurrent. If the circuit is ungrounded, then overcurrent protection is required in both conductors of a circuit. In PV systems, sources of high current are the PV modules, the batteries, backup generators, and the utility grid when used. If a circuit can be subject to overcurrents from two sources, there may be a requirement for overcurrent protection for that circuit near both sources.

Conductor ampacity (See Code Corner, Home Power 51) plays a major role in determining the need for and location of overcurrent protection. PV modules generate limited currents (compared to batteries and other sources). The module and array cables are typically sized to handle these module currents without overcurrent protection. This means that when delivering the maximum current possible from the modules into a short circuit, the cables connected to the PV array are operated at less than their ampacity under all conditions. In some designs with large (over 1 kW) arrays, overcurrent devices may be needed in the module wiring.

These same cables are usually connected to the battery system and they are not, by any means, sized to handle short-circuit currents from the battery. For this reason, overcurrent protection is needed near the battery end of the PV array wiring to protect these cables, should a fault or short circuit occur near the modules. While many PV systems use blocking diodes to stop the flow of battery current into the PV array at night, these blocking diodes cannot be relied upon to protect the wiring from short-circuit currents. When these diodes fail, they usually fail in a shorted mode and allow current to flow freely in both directions.

Although the battery-to-inverter cables are very large and sized to handle the normal operating currents in those circuits, they are not large enough to carry the battery short-circuit currents if a fault occurs near the inverter. Overcurrent protection is also required in this circuit.

Branch Circuit or Supplemental Devices
Within the two types of overcurrent devices (fuses and circuit breakers) there are two categories of devices that are established by standards written by Underwriters Laboratories (UL). The first category is the listed branch-circuit rated device. This category of overcurrent device is the more robust of the two categories and is acceptable for use in all locations in a PV system. Fuses that are listed for branch-circuit use are called "class" fuses and have class designations of T, H, RK5, RK1, CC, and the like. Circuit breakers that are used in load centers like those produced by Square D, Siemens, General Electric, and others are listed as branch-circuit-rated devices.

The other category of overcurrent device is known and listed by UL as a supplemental device. It is called a supplemental device because it is generally installed inside a piece of electronic equipment which is connected to a circuit that is protected elsewhere by a branch-circuit-rated device. In PV systems, listed supplemental overcurrent devices are allowed only in the circuits to the PV array or modules. Fuses known as midget fuses are one of the few supplemental fuses that are listed by UL with the necessary direct current (DC) ratings. Some listed supplemental circuit breakers such as those made by Heinemann and Airpax are available, but they do not plug into commonly available load centers and must be installed in custom enclosures.

DC Ratings are Needed
In all cases (fuses or circuit breakers and supplemental or branch circuit), all overcurrent devices used in PV systems should be listed by UL and rated for operation on direct-current (DC) circuits at the appropriate voltage and current. Many fuses and circuit breakers are not suitable for DC, even though they may be class type fuses or branch-circuit-rated circuit breakers.

Automotive fuses are not suitable for use in PV systems even though they are used in DC systems on automobiles. They are not tested for use in non-automotive applications and do not have the proper interrupt ratings (discussed below). In a similar vein, devices with only ac ratings (particularly the small ac-only rated, glass supplemental fuses) should not be used. AC-rated devices cannot effectively interrupt the direct currents and extinguish the long-lasting, continuous arcs that are associated with direct currents.

Most DC-rated devices have the ratings printed directly on the body of the fuse or circuit breaker. If there is any question, the manufacturer can provide the DC ratings as established by the UL listing—if there has been a DC rating established at all.

Interrupt Ratings
Particularly important in DC circuits with batteries is the interrupt rating of the overcurrent device. The high short-circuit current capabilities of batteries impose rather strenuous requirements on overcurrent devices that must interrupt fault currents from these batteries. The DC interrupt rating for a device that is rated for both DC and ac operation will be far smaller than the ac interrupt rating because of the difficulty in interrupting the direct current flow under both normal and fault conditions. Many DC-rated overcurrent devices have interrupt ratings in the 3000-5000 amp range, which is significantly lower than the tens of thousands of amps that the batteries on a typical PV system can deliver into a short circuit. Supplemental overcurrent devices usually, but not always, have lower interrupt ratings than branch-circuit rated overcurrent devices. The DC interrupt rating should also be printed on the device.

Current Limiting
Since many overcurrent devices have interrupting ratings that are inadequate, a current-limiting fuse can be installed in the same circuit. These fuses act to open a circuit so fast that the short-circuit currents are not allowed to build up to a high level. The current starts to rise to a peak value, but the quick-acting, current-limiting fuse holds it to a value that can be safely handled by other overcurrent devices on the same circuit.

For example, the common Square D residential QO series of circuit breakers has a DC interrupt rating of 5000 amps at 48 volts DC. Since these are low in cost and readily available, they are frequently selected for PV array combiner circuits and DC load centers. They are perfectly satisfactory for this use, when they are connected to the battery through a current-limiting fuse. While the fuse and its required disconnect switch are somewhat expensive, they do allow the use of the inexpensive Square D circuit breakers.

There are no UL-Listed, branch-circuit rated, DC, current-limiting circuit breakers — the mechanical delays inherent in circuit breakers prevent them from acting fast enough. There are some supplemental European circuit breakers that may eventually be listed in the U.S. as supplemental current limiting devices.

In some cases, a current-limiting fuse is not needed to protect a circuit breaker in a battery circuit. Overcurrent devices protect the cable and, when required, other current devices with inadequate interrupt ratings. Some DC-rated, UL-listed, branch-circuit-rated circuit breakers have interrupt ratings of 20,000-25,000 amps. This rating is similar to the interrupt rating on some DC-rated fuses. If this circuit breaker is the only overcurrent device in a circuit, then it can protect the conductors

and itself without the addition of a current-limiting fuse. A common use is a DC-rated circuit breaker protecting the conductors between the batteries and the inverter. It would have an overcurrent rating in the range of 100-300 amps (based on the inverter input current and the cable size) and also have an interrupt rating of 25,000 amps to deal with fault currents.

Current Ratings
The overcurrent devices used to protect PV module and array conductors should be rated at less than the ampacity of the cable (or the next higher standard value), and that rating should be at least 156% of the rated short-circuit current from the module or array. This rating will comply with the requirements established by UL and the NEC.

Overcurrent devices on other dc-load circuits should be rated at 125% of the continuous steady-state currents and, as before, always be rated less than the conductor ampacity.

The overcurrent device for the conductor between the battery and the inverter should be rated based on 125% of the inverter input current calculated at full rated ac-power output and the lowest battery voltage. The inverter efficiency should also be used. See Code Corner in Home Power 48 for an example of this calculation.

Voltage Ratings
Overcurrent devices used to protect PV module and array wiring should have a voltage rating of at least 125% of the system open-circuit voltage. The common Square D QO circuit breaker with a 48-volt rating can be used in 12-volt systems that have a 22-volt open-circuit voltage (125% of 22 is 27.5 volts), but not on 24-volt PV systems that have an open-circuit voltage of 44 volts (125% of 44 is 55 volts). Circuit breakers such as the Heinemann units have either a 65-volt or 125-volt DC rating depending on the particular unit and the interrupt rating. Many DC-rated fuses have a DC voltage rating of 125 volts, although some are rated as high as 700 volts.

Cold Fuses
Whenever a fuse is used as an overcurrent device, there should be provisions in the system to disconnect both ends of the fuse from all sources of voltage for servicing. These provisions will normally mean that there will be disconnects between the battery and the current-limiting fuses located on each ungrounded battery conductor. Other disconnects (discussed in the next Code Corner) for the PV, generator, and inverter should suffice to remove voltages from the other end of the fuse.

Summary
Keep your system from becoming a disaster — install the appropriate overcurrent devices. Overcurrent devices are required to protect the ungrounded conductors of most PV systems. They should be listed to UL Standards and have the appropriate DC voltage, current, and interrupt ratings. Current-limiting fuses are required on most battery circuits. Disconnects will be required for most fuse installations.

Access
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An NEC Article 690 Task Group, chartered by NFPA, is working on the 1999 NEC with a Technical Review Committee from the Solar Energy Industries Association (SEIA). Those wishing to actively participate should contact Ward Bower at Sandia National Laboratories • 505-844-5206

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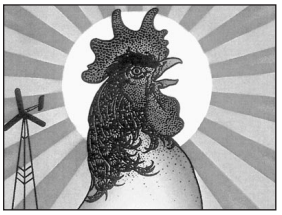


The Midwest Renewable Energy Association Workshop Schedule

MREA is a grass-roots, non-profit educational organization whose mission is to promote renewable energy and energy efficiency through education and demonstration.

Membership and participation in the MREA are open and welcome to all interested individuals and organizations.

SPRING...

April 13–14: Photovoltaic Systems
Instructor: Jim Kerbel of Photovoltaic Systems
Location: Amherst, WI Cost: $200
This course includes siting, design, and sizing, charge controllers, batteries, inverters, wiring, and installation methods of PV systems.

April 27–28: Solar Domestic Hot Water
Instructor: Chuck Gates of Altech Energy
Location: Forestville, WI Cost: $225
Through hands-on demonstrations and an actual installation of a two panel system you will learn different types and components, siting, sizing, transfer fluids, and controllers for solar hot water systems.

May 4–5: Grid-Intertie Wind Systems
Instructor: Mick Sagrillo of Lake Michigan Wind & Sun
Location: Milwaukee, WI Cost $225
This workshop covers siting, system sizing, installation, zoning, and utility issues, for utility intertie wind systems in the 3 KW to 20 KW range. There will be several site visits of working systems and equipment will be on hand for demonstrations.

May 11-12: A Place to Call Home: A Soulful Look at Alternative Building Techniques
Instructor: Mark Morgan; Builder / Philosopher
Location: Beaver Creek Nature Preserve, Fall Creek, WI Cost $250
Explore the mental and emotional processes involved in the design and construction of an alternative/renewable energy home. Workshop will include classroom discussion and hands-on work with various construction techniques including straw-bale, rammed earth tire, cord wood, earth-bermed, and passive solar designs. Fee covers housing and food for the weekend.

SUMMER...

Help install the photovoltaic and wind systems that will power this year's **Midwest Renewable Energy Fair**. (Students should have a basic knowledge of electricity)

June 12-19: PV Systems Design and Installation
Instructor: Jim Kerbel of Photovoltaic Systems, and Chris LaForge of Great Northern Solar
Location: Amherst, WI Cost: $300

June 14-16: Wind Systems Design and Installation
Instructor: Mick Sagrillo of Lake Michigan Wind & Sun
Location: Amherst, WI Cost: $100

coming in the FALL...

Sept 21-22: A Place to Call Home: A soulful Look at Alternative Building Techniques See spring workshop description.

Sept 27-29: Energize Your Home or Classroom

call or write **The Midwest Renewable Energy Association • PO Box 249, Amherst, WI 54406**
phone (715) 824-5166 • fax (715) 824-5399

Needed: *PV Volunteers for Africa.*

Solar Energy International (SEI) is organizing volunteers trained in the design and installation of small stand-alone photovoltaic systems. This pilot program, a component of SEI's INVEST Program, provides selected volunteers with an opportunity to work with small African businesses and community groups. Participants will work under the direct supervision of Energy Alternatives Africa (EAA). The EAA is a leading African organization promoting PV rural electrification.

To support this charitable program, volunteers must make a one year commitment and be responsible for paying their travel and in-country expenses. The total amount a volunteer needs to provide for the entire in-country year is approximately $5,000. Additional funds will need to be raised by SEI and EAA to cover administrative costs.

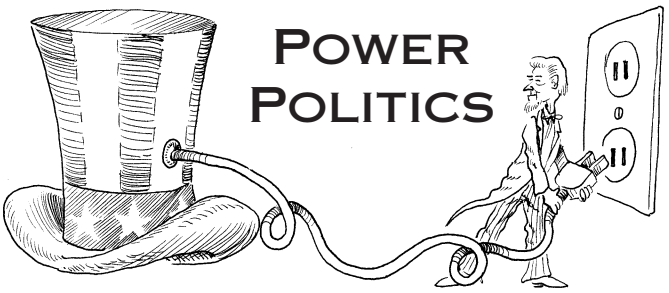
Potential volunteers are required to successfully complete SEI's PV Training program (or equivalent) as a prerequisite. The full four weeks of intensive technical training will cost each participant an additional $1700 for workshop tuition. Volunteers have two opportunities to complete the required training this year: May 28-June 21 or August 5-August 30.

To find out more about EAA please see *Home Power Magazine* issue #41.

For background information about SEI please see *Home Power Magazine* issues @21, 31, 32, 49 & 50.

Solar Energy International

PO Box 715, Carbondale, CO 81623
970-963-8855, Fax 970-963-8866 • e-mail: sei@solarenergy.org
Homepage: http://soltice.crest.org/renewables/sei/index.html



Why Energy Should Be A Presidential Issue

Michael Welch

Gaining major media's attention is the fight for who gets to be the Republican Party candidate for President. We've got the usual list of "candidates," none of which are talking about energy issues. The question we need to pose to candidates is, "Why aren't you making energy policy a Presidential issue?"

From a comprehensive viewpoint, energy should be a significant issue. What other issue impacts more areas of concern than energy? Let's explore the reasons why energy is so important as a national policy.

Environment and Energy

First, there's the environmental effects. Burning fossil fuel for power and transportation creates carbon dioxide. CO_2 is a greenhouse gas that is released when carbon-based, former life forms are burned as fuel. Greenhouse gases create an insulating layer in the earth's atmosphere which increases retention of the sun's heat. CO_2 is building up in our atmosphere. More and more of it is being released while the earth's natural ability to reconvert it back to oxygen and plant fiber is being eroded due to massive deforestation and ocean pollution. Much of that deforestation can be attributed to the need for energy in the form of fuel.

Most credible scientists (read: not corporate hacks working with polluting companies) recognize that greenhouse gas build-up may be causing a steady increase in atmospheric temperature. Admittedly, there is the possibility that our recent unusual weather patterns are the result of unknown natural cycles. It is more likely that the floods, extreme winter snows, and unusually hot summer weather can be attributed to greenhouse gases like CO_2.

Over millions of years the earth has reached a delicate equilibrium, able to sustain itself until something catastrophic has upset it. Archeologists and geologists have noted such events in the past. Such as when a meteor or comet fell onto earth, kicking into the atmosphere incredible amounts of dust, or when a huge volcanic eruption spewed massive amounts of particulates and greenhouse gases. Events like this are thought to be responsible for the ice ages and the extinction of entire orders of animals, such as the dinosaur.

We may be setting the world up for another similar result. It is one thing for nature to change the course of the world, because there's not much to be done about that. But, humans are smart enough to know better, and hopefully, change their practices.

Nuclear energy is another environmental disaster waiting to happen (again). It seems ridiculous to use a potentially unsafe, multi-billion dollar technology just to boil water to make steam to drive turbines to make electricity, when all that needs be done is point solar cells at the sun and point wind turbines at the breeze. Using nuclear, we continually create new radioactive contamination and storage sites that are unsafe for all life forms. A significant byproduct of nuclear energy is plutonium—the most dangerous substance known to humans. A meltdown or spill can pollute the environment for thousands of years.

While not as permanent, acid rain is another important result of our energy usage. Entire lakes are dying off, and our buildings, bridges, and other infrastructure are being eroded away by corrosive fallout from fossil fuel power plants that don't have effective pollution regulation. This is an easily preventable situation. We need to enact strict pollution control on both domestic power plants and those that import power into the U.S. This would make RE a much more economical option than burning carbon.

Most of us realize that these environmental problems are unnecessar, and correctable if we act now. Otherwise, in the course of less than a hundred years, humans could destroy the natural world that took millions of years to create.

National Security and Energy

There's the question of national security and the need to protect our foreign sources of oil. The Gulf War was an excellent case in point. Using the excuse of wanting to get rid of a heartless and aggressive dictator, our armies

were called on to protect the flow of oil supplies in the Middle East. Bombs were dropped, good and innocent people died, and huge sums of money were spent.

The potential need to operate this kind of strike again is touted as a reason for keeping our armies at a level unequaled by any other nation. Previously, we had the cold war to feed our insatiable military-industrial complex. Now our politicians want to keep and even raise the level of military funding. Our appetite for oil is a major factor.

I have a different viewpoint of national security than most folks. To me, the way to a secure future is to quit wasting trillions of dollars on armies that are already larger and better equipped than ALL of our potential enemies COMBINED. While we throw our hard-earned tax dollars down the military hole, our people are homeless and jobless, and our children are under-educated. Cheap, foreign labor is taking our jobs. Outside of personal automobiles, the military is the single worst polluter in the world.

Security is not determined by military might. It is promulgated by how well we live, how well we treat each other, and our ability to survive on this planet.

Justice and Energy

Then there's the moral social-justice issues of the way people are treated. Our lust for oil and energy has had a chilling effect on how we treat ourselves and others. Oil companies, uranium mining companies, coal companies, and other resource-extractors are famous for exploiting indigenous peoples and the poor. Most uranium mining has occurred and continues to occur on aboriginal lands, where the people doing the work are kept in the dark about the dangers involved, and don't realize the long term environmental impacts of what they are doing.

Companies exploiting natural resources go in and get out as fast as they can in order to maximize profits. The locals are often left with various health problems, huge, dangerous messes to clean up, and disappearing jobs. Black lung disease, radiation illnesses, piles of uranium tailings, topsoil losses from strip mining, and erosion from clear cut forests are all problems that have been foisted on relatively helpless peoples in the name of energy supply.

Utilities have had too much control over our lives. In the 50's and 60's they coerced customers into using electricity for everything in their homes with the promise of power "too cheap to meter." Now, the average household spends more than $150 a month for their utility bills. The companies then take some of the profits from ratepayers and use it to buy political influence to maintain their status quo.

When major storms occur, like California's recent windstorms, it is not so much the devastation that makes the news, but rather how many people are out of electricity. Utilities have too much influence over our lives. With small scale, decentralized renewable energy, we can once again take control of a significant part of our lives. We can control our own energy destinies.

RE also takes care of the NIMBY (not in my back yard) syndrome inherent in the energy industry. Nobody really wants to be exposed to the serious problems possible with non-renewable energy. But what does it hurt to have a 500 kw solar array just outside of town? Or a 2 kw system right on your own roof?

Economics and Energy

Most politicians claim their major concerns are jobs and the economy. RE promises to improve our lot on both fronts, but more from the worker point of view than the corporate point of view. Promoting RE right now would get our foot in the door of an international market, creating a lot of good jobs.

Note that very few of the RE products you see in *Home Power* are made in foreign countries. Sure, there are some products made overseas, but with the exception of some PV modules, utility scale wind machines, and some other minor exceptions, it is the U.S.-made products that have gained international acceptance. U.S. products are the top of the lot, and there are many new ones to be developed and exported as RE becomes more cost effective. All we ask is an even playing field for RE research and development funds. Politicians should quit favoring well-developed fossil fuel and nuclear technologies and focus on the underdeveloped RE technologies.

For utilities, it makes sense to add small, decentralized RE plants instead of the huge plants they have been building for the last 40 years. The benefits include less grid distribution construction and maintenance costs, faster construction turn-around time, less construction cost uncertainties, greater flexibility in placing the plants where they are needed, and less problems if a plant goes off line because power from one small plant among many won't be as readily missed. One of the biggest advantages of solar electric plants is that they are producing their peak power at the same time that consumer usage peaks.

The Bottom Line

The next question is why do the media and our politicians continue to ignore this crucial topic? Especially when so many of their constituents feel that energy issues are extremely important. Many Americans don't agree with the way our politicians have been handling those issues and the way government

monies have favored the fossil fuel and nuclear industries. Politicians get much of their money from those opposing the energy changes we need. Major media is owned and/or supported by the very companies that stand to lose short term profits by the enactment of a good renewable energy policy.

It is time for a change in attitude, and it is up to us as citizens, voters, and ratepayers to hold our politicians responsible for the future of our nation. The politicians are elected by the voters. If we take it, we have the power to turn them around. But we must be pro-active. Let's make energy an issue.

Here are the tools you need to make a difference in the upcoming elections. Take the time to call the candidates and grill them on their energy platforms. Take the time to educate them on the importance of energy and what it means to the future of our nation and the world.

Candidates Positions

Even though no candidates are making an issue out of energy, many have stated their positions. Energy America Education Fund, a non-partisan, non-profit New Hampshire organization, circulated a survey among candidates to find out what their positions are. Responses were received from Clinton, Dole, Gramm, Lugar, Dornan, Alexander, Forbes, Buchanan, and Keyes.

The following is from EAEF's release of this information. The survey can be accessed on the Internet at http://www.essential.org/CMEP.

"While President Clinton generally staked out stronger pro-environment positions...than his would-be Republican challengers, numerous public opinion polls suggest that all the candidates may be out of step with voters on key…energy policy issues—to their potential detriment."

"For example, a survey conducted last month [January, 1996] by…a Republican polling firm…found that nearly 60% of voters said they would be more likely to vote for a candidate who shares their energy priorities. Furthermore, they overwhelmingly favor continuing federal support for renewable energy and energy efficiency programs while reducing support for conventional energy sources such as nuclear, coal, and oil. Most of the [survey] responses ran counter to these preferences."

Points from the Survey

We will include only those candidates who are still running viable campaigns. They are Clinton, Dole, Alexander, Forbes, and Buchanan.

• Only Clinton objected to the 25% cut in FY'96 budget funding for the DOE's energy efficiency and renewable energy programs.

• Only Clinton was against abolishing the DOE itself.

• Most of the Republican candidates and Clinton expressed support for funding DOE's Weatherization Assistance Program as well as the Health and Human Services Department's Low-Income Home Energy Assistance Program. Alexander, however, endorsed proposed 40% cuts in those programs. Dole said the funding levels depend on other competing priorities, Forbes has "established no specific funding level," and Buchanan did not share his views on this issue.

• When asked about a 35% cut in EPA funding as approved by the House of Representatives, Buchanan was in support of such a cut. Dole was willing to support smaller reductions as were approved by the Senate, while Alexander would retarget at least some funding to the states "to keep their drinking water clean." Clinton is strongly opposed to EPA cuts of this magnitude. Again, Forbes noted that he has "established no specific funding level."

• With regard to appliance efficiency standards, Clinton maintains that they "have saved consumers billions of dollars in the past 10 years." Alexander noted that "they do need to be reformed," and Dole indicated that the marketplace, rather than the federal government, should dictate efficiency standards. Forbes favored phase-out of the standards, while Buchanan offered no response.

• Alexander, Buchanan, and Forbes explicitly support the construction of new nuclear plants in this country. Dole was also in favor of nuclear plant construction, noting that the problem of disposing of nuclear waste "needs to be solved." Clinton favors "research and development funding to help develop more cost-effective nuclear plant designs" while letting "the market and the public choose the technology and fuels for future electricity generation—not the government."

• Alexander and Dole support building an interim high level nuclear waste facility in Nevada. Buchanan offered no comment while Forbes said that he was "undecided pending further study." Clinton "opposes building anywhere a temporary storage facility…until scientific investigation on a permanent disposal site is further along."

• All candidates except Buchanan, who offered no comment, and Forbes, who again, was "undecided pending further study," generally supported the transfer of federal land for the proposed Ward Valley, California low-level nuclear waste facility. Clinton, who earlier vetoed a measure he claimed lacked "any binding

commitments for public safeguards" said his support is conditioned on "the proper health and safety standards [being] in place," while Alexander wants the project to be "scientifically and environmentally sound."

• All the Republican candidates favor the opening of the Arctic National Wildlife Refuge (ANWR) to oil exploration and drilling. Clinton is opposed, noting that the region "is a rare, pristine wilderness that should be preserved… [and] there is more oil in energy efficiency."

• No candidates supported raising auto fuel efficiency standards. Clinton prefers pursuing a partnership with the auto industry "to develop a new generation of high-performance, affordable vehicles [that are] up to three times more fuel efficient." Dole would rely on market-based mechanisms to get the really inefficient and polluting cars off the road."

• Only Clinton supports cutting "greenhouse gas" emissions to 1990 levels by the year 2000. Alexander acknowledges the seriousness of the issue, but wants to act only in conjunction "with other countries." Forbes "questions the need for restricting the United States' ability to create jobs for our people based on a global warming theory which is unproven." Buchanan did not respond.

• All the candidates support applying cost/benefit tests to all new and existing federal environmental and energy regulation. Clinton would oppose its use if it "would cause undue delay or litigation or would roll back health, safety, and environmental protection." Dole wants to "emphasize sound science…and be careful of pursuing small risks at great costs."

• Finally, all the Republican candidates other than Buchanan, who did not respond, favor repealing the Public Utility Holding Company Act. Clinton opposes repeal because the law "still serves as an important safeguard for consumers [but] as the electric utility industry becomes more competitive, the Administration will assess the prospects for undertaking statutory reforms of PUHCA."

Access

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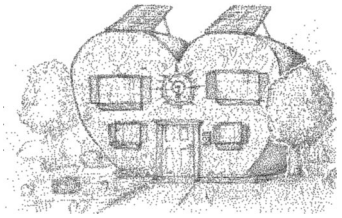
Energy America Education Fund, Newmarket Rd. Box 201, Warner, NH 03278 • 603-431-2499

Home & Heart



Kathleen Jarschke-Schultze

Our local appliance store was having a sale. Ten percent off everything in the store. Bob-O was going there for some parts for a job he had going. I said, "While you are there why don't you take a look at the dishwashers and tell me what model you think would be good for us. Remember it has to be quiet, so look at the insulation closely."

Surprise!

I had also asked him to pick up a few parts for a Dremel stand I am making. He handed me the parts and the receipt and said, "Here's the receipt in case those aren't all the parts you want. You better check."

The receipt had all the parts I needed listed plus a black Asko model 1355 dishwasher, on order. Since I had chosen black when I got my Premier gas range he figured I would want a black dishwasher to go with it. He was right. Now I just had to wait a few weeks for it to arrive at the store.

Asko 1355

"Gee," Bob-O said, "I guess I should have picked up some literature on it so you could see what it looks like." This was not a problem. I went to the dishwasher research file in my office and pulled out a color brochure on the available Askos and there it was.

In an independent study, the literature said, 97% of the home owners surveyed judged Asko dishwashers to be noticeably quieter than the newest models of other leading manufacturers. The insulation used is a blanket of asphalt and heavy felt padding that absorbs ten times more sound than the fiberglass insulation that is the norm in other brands. That sounded and looked good to Bob-O!

Energy Efficiency

A report by the American Council for an Energy-Efficient Economy (ACE^3), an independent research group, has proven the Asko to be the most energy efficient unit available.

The Normal cycle of any model of Asko uses only 4.6 gallons of water. The Pots and Pans cycle uses 5.8 gallons. The Light cycle uses 3.7 gallons. After hooking up the unit we found that the water consumption was so low that our Myson on-demand water heater was not heating the water as hot as we would like. The Myson has to have 3/4 gallon per minute flow to fully turn on. The Asko uses water so conservatively that there is not time for the water to get hot in the pipes. We remedied this by turning on the kitchen faucet for about 20 seconds just as we start a load of dishes. This fills the pipes with hot water for the unit to use.

This simply will not be an issue Spring through Fall when our wind turbine gives us surplus power to heat water or when we have enough sun for our Thermomax solar water heater to work. It has been a very gray winter this year. There is a Temp Boost option on the Asko but we choose not to use that to heat the water.

Controls

The 1355 is the only model with manual controls. All other models have electronic controls, which are probably a phantom load. The control panel is very basic. There are two buttons and a knob. One button is for the Temp Boost, on or off. When it is on, the heating element will heat the water to 140° F no matter what the temperature was to start with.

The other button is for heating-with-fan dry, on or off. This is another option we choose not to use. At least not until the windy seasons when we have lots of surplus power. When the unit gets to the dry cycle we just open the door and pull out the racks to let the dishes air dry. We do wish there was some sort of indicator on the control panel to let us know when the unit enters the dry cycle. So far we have been opening the door when the sound of water stops. Unfortunately, the unit is so quiet we miss it sometimes.

The knob turns to start the washer. There are six numbers indicating which cycles are available. You turn the knob so that the cycle number you want is at the top. When we open the door to air dry the dishes we have to be sure to turn the knob to off. The cycle would just pick up where it left off if we didn't. The brochure assures us that if there is a power outage our dishes would resume being washed when the power came back on. Since power outages don't happen at the We-Own-It Utility Company we must adjust this feature to our needs.

There are six cycles to choose from. #1, Rinse and Hold. #2, Pots and Pans. #3, Normal Wash. #4, Light Wash. #5, Rinse. #6, Plate Heating. We don't use Rinse and Hold, we rinse by hand right away. We don't use the Light Wash for the same reason we don't use the delicate cycle on the clothes washer. When we do a load of dirty things it's a whole load of dirty things. I am looking forward to using the Rinse cycle during the canning season. My friends that have dishwashers say it is really a time and hassle saver to be able to rinse

and heat those canning jars for filling. Lastly, I don't see myself using the Plate Warm cycle at my next dinner party. In fact, at my next dinner party the guests will probably be rinsing and loading their own dishes. We are not big on formality here.

Installation
The brochure had the outside dimensions of the unit so I was able to prepare its space before it arrived. The dimensions were correct, but the cabinets were not cooperative. Even though I can't saw a straight line to save my life, there is nothing so fun as modifying or making things for your home. I did the cabinet work for the unit. Bob-O will do the cut on the remaining cabinet door. It must be shortened, and that cut absolutely must be straight. Everything I did is hidden by the installation. You know, when a cabinet maker makes your kitchen cabinet he can walk around it 360° and put nails wherever he wants. This makes for much frustration when remodeling his work after it is attached to your kitchen walls. However, using a combination of electric, hand, and Japanese pruning saws, I was able to finish my task.

Bob-O says the installation docs are poorly written. The instructions are general and don't specify step by step directions. The line drawings are adequate and do help clarify the instructions. The parts list for the additional plumbing and electrical parts needed was accurate. The unit has to be hard wired on its own circuit.

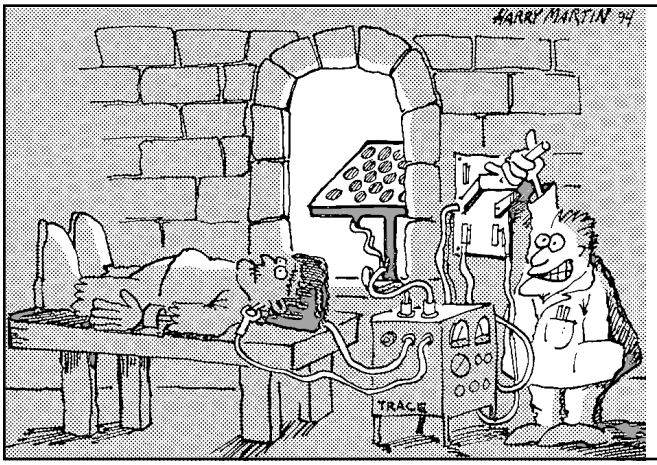
Performance & Cost
As of this writing we have washed three loads of dishes. This is not enough for me to judge performance. By the next issue of HP I will have more experience and, I am sure, more comments.

The Asko 1355, the least expensive model of Asko dishwashers offered, was $810. This is really expensive. I will not print the whole warranty here but there is a one year, five year, and 25 year warranty on various parts of the unit.

Access
Kathleen Jarschke-Schultze is not doing dishes by hand at her home in northern-most California, c/o *Home Power Magazine*, PO Box 520, Ashland, OR 97520 • 916-475-0830 • Internet E-mail: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

Asko, Inc. PO Box 851805, Richardson, TX 75085-1805

ACE^3, Bill Roush of Solar Electric Systems at 13700 W. 108th St., Lenexa, KS has about 100 copies of ACE^3's Energy Efficient Appliances book. If you send him two 32¢ stamps he will send you a copy. This offer is good while supplies last.



HAPPENINGS

AFRICA
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CANADA
A do-it-yourself Micro Hydroelectric course for those interested in harnessing water power for individual use will be held Friday May 24 to Sunday May 26, 1996 at Simon Fraser University, British Columbia, Canada. The course covers the range from battery-based systems up to 50kW AC-only systems and includes information on equipment, safety, licensing, and cost. Course participants will learn to assess stream capacity, size system components, estimate costs, and install a system. The course concludes with a field trip to an operating micro hydroelectric system. The instructor is Robert Mathews, Appropriate Energy Systems. The fee is Cdn $225 (Cdn $195 is registered by April 30).

To register or for more information contact the Applied Sciences Continuing Education Program, Simon Fraser University, Burnaby, BC, Canada V5A 1S6 or phone 604-291-4904, fax 604-291-3851, e-mail: cs_appliedsc@sfu.ca

A Sustainable Future: How Do We Get There From Here? A conference retreat sponsored by the Solar Energy Society of Canada Inc., June 9-June 12, 1996. This three day retreat will focus on topics that are key to the success of a sustainable energy future: policy options, technical developments, commercialization, and required action. For more information contact Solar Energy Society of Canada Inc., 250-2415 Holly Lane, Ottawa, ON K1V 7P2, Canada, 613-523-0974, Fax 613-736-8938, e-mail: solar@worldlink.ca

The "Alberta Sustainable House" is now open for public viewing every Saturday 1:00-4:00 PM free of charge. The first of its kind in Canada, the project emphasizes cold-climate state-of-the-art features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Already in place: R17 windows, multi-purpose masonry heater, solar hot water, greywater heat exchangers, LED and electroluminescent lighting, solar cookers, and others. Under development: hydrogen fuel cells, Stirling co-generator, Tesla bladeless steam turbine, and others. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc/Alternative & Conservation Energies Inc, 9211 Scurfield Dr NW, Calgary Alberta T3L 1V9, Canada; 403-239-1882, Fax: 403-547-2671

The Institute for Bioregional Studies was founded to demonstrate and teach recent ecologically-oriented, scientific, social and technological achievements that move us toward ecological, healthy, interdependent and self-reliant communities. For more info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada; 902-892-9578.

CUBA
CubaSolar'96, Alternative Energy Delegation to Havana and Santiago de Cuba, May 31–June 9, 1996. Meet with Cuban alternative energy practitioners who are pioneering Cuba's conversion to solar, wind, hydro, biomass conversion and other alternative methods of generating and conserving energy.

Attend the Second Annual International CubaSolar'96 Conference and Exposition in Santiago de Cuba and Guantanamo with a focus on renewable energy and rural energy needs; solar energy in agriculture and agro-industry; bioclimatic architecture; ecotourism; culture and energy consciousness; research technologies and production of equipment for the utilization of renewable energy sources.

Explore opportunities to develop long term relationships with Cuba's alternative energy researchers and to help Cuba move toward energy self-sufficiency.

Cost of the trip is $1,300 which includes: round trip airfare from Cancun, Mexico to Havana, Cuba; visa fees, double room accommodations, transportation in Cuba, breakfast and dinner each day, translation of an eight hour per day program, expert trip leaders and reading materials. We will also arrange personal meetings to suit your particular interests. Partial scholarships are available. Space is limited. For more information contact: The Reality Tour Program, Global Exchange, 2017 Mission St #303, San Francisco, CA 94110, 415-255-7296, 800-497-1994, e-mail: globalexch@igc.org

GERMANY
"Bayern Solar 1996" to be held 19–21 July. Rally around Lake Cheimsee in Southern Germany (Bavaria) using electrically powered vehicles in four different classes. For details or more information contact Mr Werner Hillebrand, Weldenstrabe 19, 85356 Freising, Germany. Tel. 49-8161-871148 Fax: 49-8161-82848.

SWEDEN
1996 European Union Wind Energy Conference and Exhibition, May 20–24, Goteberg, Sweden. Contact phone 49-89-7201-232, Fax 49-89-7201-291

SWITZERLAND
The Environmental Assessment Association (EAA) conference on European Environmental Issues is being held on May 20,1996 in Geneva, Switzerland. Informative addresses will be presented covering current European Environmental issues including Environmental Inspections, ISO 14000, and Legal Liabilities relating to the Environmental Industry. Attendees from more than one dozen countries will range from Corporate Environmental Professionals to Individual Consultants.

For more information on the Geneva conference or the Association , contact EAA at (602) 483-8100, Fax (602) 998-8022, e-mail: eaa@iami.org, Internet: http://iami.org/eaa.html

NATIONAL
Energy info on the Internet can now be accessed via the Energy Efficiency and Renewable Energy Network (EREN), a multimedia WWW server developed by the DOE. Check it out at http://www.eren.doe.gov or contact: Energy Efficiency and Renewable Energy Clearinghouse, PO Box 3048, Merrifield, VA 22116; 800-363-3732; e-mail: ENERGYINFO@delphi.com

American Hydrogen Association, national headquarters, 216 South Clark Dr, Ste 103, Tempe, AZ 85281, 602-921-0433, fax 602-967-6601, e-mail: aha@getnet.com "Prosperity Without Pollution" web site: http://www.getnet.com/charity/aha

Energy Efficiency and Renewable Energy Clearinghouse (EREC) is offering a free booklet, Energy Efficient Lighting (FS141) that covers the technologies developed during the past 10 years that can help cut lighting costs 30%–60% while enhancing lighting quality and reducing environmental impacts. Also available the free publication, Energy Efficient Windows (FS216), for homeowners who want to find out how windows can reduce a home's heating and cooling costs. For free copies contact EREC: Phone: 800-DOE-EREC (363-3732); mail: EREC, PO Box 3048, Merrifield, VA 22116; e-mail: energyinfo@delphi.com; TDD: 800-273-2957; The information can also be downloaded via the DOE's BBS at 800-273-2955 or via internet: http://www.eren.doe.gov

The Learning to Water Wise and Energy Efficient is a program designed for children, grades 4 thru 8 to teach tomorrow's energy consumers wise habits that they can use for many years to come. Not only do teachers and students receive the instructional materials to learn the concepts and principles of conservation, but they also receive the hardware they need to apply what they have learned. The program is sponsored by local utilities or companies that want to make an environmental difference in their community. For information on helping implement the program in your community contact: Sarah Quarante, Energy Technologies Laboratories. 2351 Tenaya Dr, Modesto, CA 95354, 800-344-3234, fax 209-529-3554.

The U.S. Department of Energy's Office of Building Technologies (OBT) through NREL (National Renewable Energy Laboratory) is offering bulletins describing current research in heating, ventilating and air-conditioning (HVAC) that is being conducted by OBT and its labs.The free bulletins are Thermally Activated Heat Pumps, which discusses efficient gas-fired heat pump technology that heats and cools buildings without producing CFCs. Also,

HBCU Program at Tennessee Sate University discusses research in alternative refrigerants. Limited quantities of these bulletins are available by contacting NRELs Document Distribution Service at 303-275-4363, fax 303-275-4053 or evanss@tcplink.nrel.gov (e-mail)

Sun Day, April 21, 1996, is an ongoing nationwide, grassroots, organizing and educational campaign to promote improved energy efficiency, renewable energy (solar, wind, biomass, solar hydrogen, geothermal and hydroelectric) technologies, electric vehicles, and sustainable agriculture as solutions to global climate change, energy imports, acid rain, radioactive waste, and other energy-related environmental problems. The campaign was formally launched on Earth Day 1992, with activities sponsored throughout the United States. Once again, many participating organizations will be sponsoring fairs, conferences, educational programs, political actions, and other events. If you are interested in participating contact Ken Bossong, Sun Day: A Campaign for a Sustainable Energy Future, 315 Circle Ave #2, Takoma Park, MD 20912-4836, 301-270-2258, Fax 301-891-2866.

EcoMall, A Place to Help Save the Earth. http://www.ecomall.com • Eco Companies/Products • Daily Eco News • Renewable Energy • Eco Restaurants • Activism • Communications • Business to Business • Eco Data Bases. For more info, please call: (212) 289-1234 or write 75 Spring Street 4th Floor, New York, NY 10012. E-Mail: ecomall@internetmcl.com

ARIZONA

The State of Arizona is now offering a tax credit for installation of all types of solar energy systems. A solar technician certified by the Arizona Department of Commerce must be on each job site. For info contact ARI SEIA; 602-258-3422.

Solar Cooked Resigns! Bring your oven to the 14th Annual Tucson Solar Potluck and Exhibition. One of the longest running solar events in the nation. Solar ovens extraordinaire! Electric cars, photovoltaics and more. Live music powered by the Sun. This is a classic event and aimed at those who want to have fun in the desert sun and learn about solar cooking. Camp amongst the mesquites at the beautiful Catalina State Park. Share solar cooked food in the evening potluck. When—May 4, 1996, Where—Catalina State Park, Tucson, AZ, Time—All day and into the night, camping on site ($3.00 per car load entry fee for State Park). Contact: Citizens for Solar, PO Box 36744, Tucson, AZ 85740-6744, or call Toby at 520-292-9020.

ARKANSAS

Sun Life is now conducting "Third Saturday Seminars" on inexpensive building techniques. Their focus is to teach home building from materials that can last a thousand years and cost less than conventional wood-framing. These are hands-on, all-day workshops. Contact Loren at PO Box 453, Hot Springs, AR 71902.

CALIFORNIA

The California Energy Commission's HomePage address is: http://www.energy.ca.gov/energy/homepage.html. A wealth of information on the Energy Commission, news releases, notices about hearings and workshops, an energy events calender, information on energy education for students, parents, and teachers, and hypertext links to more than 400 web sites that deal with all aspects of energy. Also available free is the 1996 Electricity Report (ER96). The Report establishes policies on electricity production and consumption and contains assessments of electricity demand and supplies. For more information about the Commission's Internet site please contact Bob Aldrich, e-mail: boba@energy.ca.gov or call 916-654-4989.

The Solar Living Institute 1996 Workshop Schedule: April 13—Planning & building your renewable energy home, April 14—Organic gardening & drip irrigation, May 11—Realizing the Dream—planning & buying the perfect country home property & developing your homestead, May 12—Sustainable building and eco design, June 8—Planning and building your renewable energy home, June 9—Organic gardening & drip irrigation, July 13—Strawbale construction, July 14—Sustainable building & eco design, August 10—Realizing the Dream—planning & buying the perfect country home property & developing your homestead, August 11—Planning & building your renewable energy home, September 14—Strawbale construction, September 15—Planning & building your renewable energy home. Each day-long workshop costs $100 and includes a catered vegetarian box lunch. To register or for more info contact: Real Goods Institute for Solar Living, 555 Leslie St, Ukiah, CA 95482-5507, 800-762-7325.

The Grand Opening of the Real Goods Solar Living Center will be held June 21–23 at their new location in Hopland, CA. For more info contact, Karen Hensley, Real Goods, 555 Leslie St, Ukiah, CA 95482-5507, 800-762-7325.

COLORADO

Solar Energy International (SEI) is offering "hands-on" workshops on the practical use of solar, wind, and water power. The 1996 Renewable Energy Education Program (REEP) features one and two week sessions: Solar Home Design—May 6–17; Environmental Building Technology (straw bale, adobe, rammed earth, & natural building) weekends—May & September; PV Design & Installation—May 28–June 7 & August 5–16; Advanced PV—June 10–21 & August 19–30; Solar Cooking—July 1–3; Microhydro Systems—July 8–19; and Wind Power—July 22-August 2. Experienced instructors and industry representatives teach how to build homes and RE systems. Learn in classroom, laboratory and through field work. The workshop series is for owner-builders, industry technicians, business owners, career seekers and international development workers. The small, intensive and fun workshops may be taken individually or as a comprehensive program. The cost is $450 per week. SEI is a non-profit educational organization dedicated to furthering the practical use of RE technology. Contact: SEI, PO Box 715, Carbondale, CO 81623 or call 970-963-8855, Fax 970-963-8866, e-mail—sei@solarenergy.org

Visit the new National Wind Technology Center operated by the National Renewable Energy Laboratory, just outside of Golden, CO. The facilities assist wind turbine designers and manufacturers with development and fine-tuning and include computer modeling and test pads. Call in advance, 303-384-6900, Fax 303-384-6901.

Windpower '96, June 23–27, Denver, CO Contact: Linda Redmond, AWEA, 122 C St NW, Fourth Floor, Washington, DC 20001, phone 202-383-2500, fax 202-383-2505.

The US Department of Energy and its National Renewable Energy Laboratory will host the World Renewable Energy Congress IV in Denver from June 15–21, 1996. Conference topics will include photovoltaics, solar thermal, wind energy, biomass, energy efficiency, economics and institutional issues, global and regional economic development, and environmental issues. The latest in energy efficiency and renewable energy equipment will be on display. More than 200 speakers have been invited and 500 abstracts for technical papers been received. Abstracts are still being accepted. For more information contact Bob Noun, 303-275-3062; Professor Ali Sayigh 1734-611634(UK), or Steve Hauser, chairman of the technical committee 303-384-7416

Western Colorado Congress Sustainable Living & Energy Fair is back, bigger and better than ever. Booths, demonstrations, and workshops will feature renewable energy, energy-efficient design, alternative building methods, holistic ranching & range management, organic food production, aquaculture, sustainable community design.

The Fair will be held May 11–12, 1996, at Columbine Middle School, Montrose, Colorado. Admission is free. For more information contact WCC, PO Box 472, Montrose, CO 81402, or call Christiane at 970-249-1978.

The Third International Symposium on New Energy, April 25–28, 1996, Denver Hilton South Hotel, Denver, CO. Topics will include space power generators, over unity and free energy machines, scaler wave theory, magnetic motors, vortex mechanics, cold fusion, electrostatic generators, nuclear isotopes, hydrogen, motional magnetic fields, zero point energy, N-Machines, homopolar generators, transmutation of elements, anti-gravity devices and environmentally friendly energy sources. For additional information call or write: International Association for New Science (IANS), 1304 S College Ave, Fort Collins, CO 80524, 970-482-3731, fax 970-482-3120.

IOWA

The Iowa Renewable Energy Association is sponsoring the second annual Earth Day Tour on Sunday afternoon April 28, 1996. Systems with thermal solar space heating and swimming pools, photovoltaics and wind, and energy efficient and non-toxic housing will have open houses at many locations throughout Iowa. If you have a system you would like to display please get in touch with us. For details contact Prairie Technologies Ph 319-338-0836, Fax 319-351-2338, or PO Box 2132, Iowa City, IA 52244.

OREGON

APROVECHO RESEARCH CENTER offers 3 month training sessions in appropriate technology, sustainable forestry and organic gardening. Classes begin June, September, January (1 month in Mexico), & March. Daily classes 8:30-5:30. Cost is $500.00 per month, includes room, board. For more info: 80574 Hazelton Rd., Cottage Grove, OR 97424. (503)942-8198

NEW YORK

Solar Energy International (SEI) is offering a special workshop for the convenience of Northeasterners who want to get their hands-on!

PV Design & Installation will be a one week workshop Monday October 14 through Saturday October 19. Instruction will be conducted at an off-grid location near Woodstock, NY. The workshop tuition cost for all six days is $450.

Workshop topics include: Solar site analysis, system sizing, PV modules, controllers, batteries, inverters and appliances, demonstrations, lab exercises and hands-on installation. No prior experience or training is required—everyone is welcome!

For more information contact: SEI, PO Box 715, Carbondale, CO 81623 or call 970-963-8855, Fax 970-963-8866, e-mail—sei@solarenergy.org

For local housing & logistical information please contact SEIs local co-sponsor: Larry Brown at Sun MOuntain, PO Box 1364, Olivebridge, NY 12461, 914-657-8096.

The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516

May 10–17, 1996, the 8th Annual American Tour de Sol Road rally championship for electric and solar cars from New York to Washington, DC. For more information: NESEA, 50 Miles St, Greenfield, MA 01301, 413-774-6051, fax 413-774-6053.

NORTH CAROLINA

SOLAR '96, National Solar Energy Conference, featuring the 25th ASES Annual Conference and the 21st National Passive Solar Conference, April 13–18, 1996, Asheville, NC. For more information contact, American Solar Energy Association, 2400 Central Ave Ste G-1, Boulder, CO 80301

Solar Energy International (SEI) is offering a special one week workshop on PV Design & Installation and a three day Microhydro Systems workshop. Both will be held in Asheville coinciding with Solar '96, the National Solar Energy Conference. The PV workshop will be held the week before Solar '96, April 8–12, and costs $450. The Microhydro workshop the week after, April 19–21 and costs $300. Contact: SEI, PO Box 715, Carbondale, CO 81623 or call 970-963-8855, Fax 970-963-8866, e-mail—sei@solarenergy.org

OHIO

The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more information: Larry Dussault, GLEAA, 568 Braxton Pl E, Westerville, OH 43081-3019, 800-GLEAA-44, 614-899-6263, Fax 614-899-1717. Internet: DUSSAULT@delphi.com

Solar and wind classes taught at rural solar and wind powered home with utility back-up. Maximum of 12 students. Must advance register. $40 fee per person, $45 per couple and lunch is provided. Please advise of dietary restrictions. Class #1 will be full of technical info, system design, system sizing, and NEC compliance, etc. Students will see equipment in use. Students may also choose class #2 and set-up a system (hands-on training), equipment selection, installation of modules, mounts, controller, inverter, and battery bank.

Dates: Apr. 20, May 18, Jun. 15, Jul. 13, Aug. 10, Sept. 7, Oct. 5, Nov. 2, Dec. 7. All classes held from 10:00 am - 2:00 pm on Saturday. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537.

TENNESSEE

Bioenergy '96, The Seventh National Bioenergy Conference, September 15–19, 1996 in Nashville, TN. (Geared toward industry and cities) Call for papers, abstract deadline March 1, 1996. For more info contact the host, Southeastern Regional Biomass Energy Program, Tennessee Valley Authority, CEB 3A, PO Box 1010, Muscle Shoals, AL 35662-1010

TEXAS

ARRL West Texas Section Convention and the Key City Amateur Radio Club Hamfest, May 4–5, 1996 in Abilene, TX. For more information call Peg Richard, KA4UPA, at 915-672-8889, or write Key City Amateur Radio Club, PO Box 2722,, Abilene, TX 79604.

WASHINGTON DC

May 10–17, 1996, the 8th Annual American Tour de Sol Road rally championship for electric and solar cars from New York to Washington, DC. For more information: NESEA, 50 Miles St, Greenfield, MA 01301, 413-774-6051, fax 413-774-6053.

VIRGINIA

Sixth Annual Tour of Solar Homes on May 19th. Tour is co-sponsored by the Virginia Solar Council and the Montgomery County Sierra Club. Tour homes include PV, passive heating, solar hot water and super-insulation. House are located in MD, VA and D.C. Tickets $15 (couple) and $10 (single) are tax deductible. Order by mail or tickets are available at some local stores. Volunteers are needed. • Virginia Solar Council, 6712 S. Kings Hwy, Alexandria, VA 22306 • 703-768-3108 • berger@ssims.nci.nih.gov

WISCONSIN

The Midwest Renewable Energy Association Spring Workshop Schedule. April 13–14: Photovoltaic Systems, Instructor: JIm Kerbel of Photovoltaic Systems, Location: Amherst, WI, Cost: $200—This course includes siting, design and sizing, charge controllers, batteries, inverters, wiring, and installation methods of PV systems. April 27–28: Solar Domestic Hot Water, Instructor: Chuck Gates of Altech Energy, Location: Forestville, WI, Cost: $225—Through hands-on demonstrations and an actual installation of a two panel system you will learn different types and components, siting, sizing, transfer fluids, and controllers for solar hot water systems. May 4–5: Grid-Intertie Wind Systems, Instructor: Mick Sagrillo of Lake Michigan Wind & Sun, Location: Milwaukee, WI, Cost $225—This workshop covers siting, system sizing, installation, zoning, and utility issues for utility intertie wind systems in the 3 KW to 20 KW range. There will be several site visits of working systems and equipment will be on hand for demonstrations. May 11–12: A Place to Call Home: A Soulful Look at Alternative Building Techniques, Instructor: Mark Morgan, Location:Beaver Creek Nature Preserve, Fall Creek, WI, Cost $250—Explore the mental and emotional processes involved in the design and construction of an alternative/renewable energy home. Includes classroom discussion and hands-on work with various construction techniques including straw-bale, rammed earth tire, cord wood, earth-bermed, and passive solar designs. Fee covers housing and food. June 12–19: PV Systems Design and Installation, Instructors: Jim Kerbel of Photovoltaic Systems and Chris LaForge of Great Northern Solar, Location: Amherst, WI, Cost: $300. Help install the photovoltaic and wind systems that will power this year's Midwest Renewable Energy Fair. (Students should have a basic knowledge of electricity). Fees for pre-Energy Fair Workshops cover instruction, handouts, and camping at the Portage County Fairgrounds. June 14–16: Wind Systems Design and Installation, Instructor: Mick Sagrillo of Lake Michigan Wind and Sun, Location: Amherst, WI, Cost: $100. Sept. 21–22: A Place to Call Home: A Soulful Look at Alternative Building Techniques: (see description for workshop May 11–12 above). Sept. 27–29: Energize Your Home or Classroom, Instructors: MREA Staff and others, Location: Central Wisconsin Environmental Station, Amherst Junction, WI. Cost: Please call MREA office. Learn more about energy conservation and renewable energy through experiments and demonstrations. Energy education activities, classroom projects, and curriculum ideas for grades K-12 and youth groups will be explored. Tour alternative energy homes in the area. Co-sponsored by the Central WI Environmental Station, Midwest Renewable Energy Association and WI Center for Environmental Education. 1 UWSP credit available. MREA is a grass-roots, non-profit educational organization whose mission is to promote renewable energy and energy efficiency through education and demonstration. Membership and participation in the MREA are open and welcome to all interested individuals and organizations. Significant others may attend with you for 1/2 price. For more information call or write MREA, PO Box 249, Amherst, WI 54406; phone 715-824-5166, fax 715-824-5399

The Seventh Annual Midwest Renewable Energy Fair will be held June 21–23,1996, at the Portage County Fairgrounds in Amherst, Wisconsin. Contact Midwest Renewable Energy Association, PO Box 249, Amherst, WI 54406, 715-824-5166.

the Wizard speaks...

Free Energy Update

From zero-point energy conversion to cold fusion, technologies are being developed which show promise for near and mid-term commercial development. Here is a small selection of current research efforts.

Don Smith, of Dallas, Texas, has developed a device based on Tesla coil technology. It is claimed that a version the size of a cigar box could power an electric vehicle.

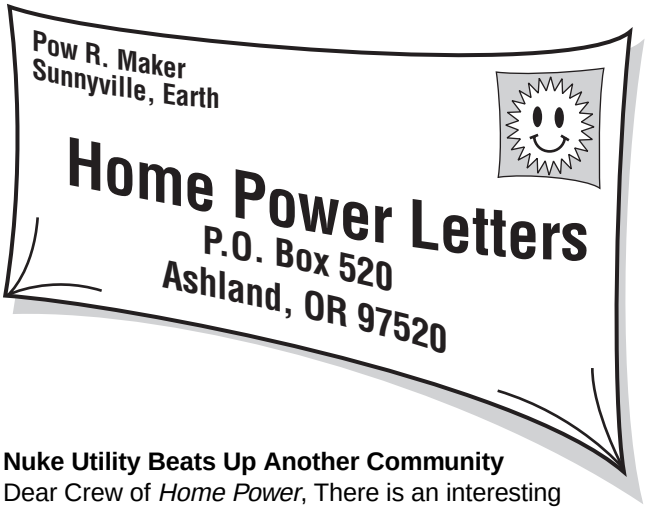
Clean Energy Technologies, Inc (CETI), also based in Dallas,Texas, has created a working cold fusion device. It is said to have produced many times its input power in various tests and demonstrations.

Yasunori Takahashi, of the Sciex Corporation of Japan, has discovered a new and more powerful type of magnet. In conjunction with his new magnetic motor, these magnets could be very effective in electric vehicles and battery charging. This motor needs a battery only for starting and then can run on its own.

The charge clusters of Dr. Kenneth Shoulders (U.S. Patent 5,018,180) and the E-dams of Dr. Wingate Lambertson both show promise in the free energy area. They create energy by tapping the zero-point field.

Bruce Peralt has rediscovered technology first discovered by T. Henry Moray. This technology works by transforming radiant cosmic energy. Mr. Peralt claims to have a 250 watt working prototype. He is currently developing a 20 kilowatt device which will be the size of two breadboxes.

If one of these or similar technologies comes to fruition, we could have free and clean energy by the turn of the century.Even if these fail, we still have solar power. Solar power can create all the energy we need. All it takes is the will to implement it.



Nuke Utility Beats Up Another Community

Dear Crew of *Home Power*, There is an interesting situation developing in Northern Illinois concerning property taxes and the Commonwealth Edison Byron Nuclear Station. Ogle County is a rural farming area with a fairly small tax base. When Com-Ed started construction of Unit #1 in the 1970's, the area contained few commuters or corporate executives. The Byron Station brings in 2/3 of the county tax monies. For the last ten years, Com-Ed has been fighting their assessment, saying it is way too high. A Property Tax Appeal Board ruling has just reduced the assessed amount of the plant by 60%. The residents are facing a six year refund to Com-Ed of over $200 million and a big tax hike to cover the reduced budgeting available!

What does this mean to the locals? Plenty! As you can see from the included newspaper articles, the residents are panicking. For the last twenty years, while other towns in the county were facing bankruptcy in their school districts, Byron was adding sports complexes and extravagant additions. The average teacher salary in Byron is $55K, while only $28K elsewhere. Hordes of developers have been swallowing up cheap prime farm land as thousands of yuppie 'barn' sized houses have popped up in the Byron school district. Only a thirty minute drive from the city of Rockford, people have been flocking away from the gangs and crime of the city to come to the peace and quiet of the small town of Byron (who spends more than triple on the school children per capita). The big fly in the ointment has just bitten really hard as all of the new residents are faced with paying $6K for their property taxes that cost only $2K before. The big losers are the small farmers who have a lot higher taxes and didn't want the power plant nor the new neighbors (who take the farmers to court because the tractors are too noisy and their pigs too smelly!). The local residents defend the extravagant school spending saying that living next to a nuclear power plant is dangerous and the power company should pay a lot extra to make it worth while! What will the schools do in forty years when the plant gets decommissioned for the next 50,000 years? What will the residents do when their big yuppie homes sit on the real estate market for five years at 50% losses? It looks like the fun is just beginning. I'm glad I live a whole county away (still paying 10.7 cents per kWh).

Perhaps if more of the residents had invested in solar or wind power, the picture would of turned out differently. You can't tax the sun nor wind, but you can draw big taxes from a power station. I hope in the future that the township assessors realizes the value of a home power station and treats it accordingly.

The above controversy is just one more example that the nuclear power industry has failed to properly think through the actual costs to do business.

Commonwealth Edison has put a nice multi-colored flyer in this month's billing statement saying that they have voluntarily frozen their electric rates at 10.7 cents per kWh for five years. What they didn't say was that they are swinging a deal to have the public pay for over two billion dollars in cost overruns attributed to building units 1 and 2. What a deal! Since Illinois is not even considering net billing, our earth sheltered home will be constructed 100% off-the-grid where our children will not glow in the dark and our garden is safe to eat! Take care, Dave and Sheila Knapp and Family, Winnebago, Illinois

Hello Dave and Sheila, Think of the utility employing solar or wind produced electric power. These RE sources have big advantages for utilities as well as independent home power systems. First the RE plants are quickly and cheaply installed in comparison with building a nuclear power plant. RE can be on line in a matter of months while it takes years (with associated cost raises and overruns) to complete a nuke. The cost of RE is far cheaper since the systems are modular—the utility can build what they can afford rather than betting the entire company on a project that won't be finished and on line for years. The solar and wind sources are distributed which reduces the need for expanding the power lines. And finally, RE is safe for the environment so the utility doesn't have the potential of disaster and cleanup. I have no doubt that in the future all electric power power will be made from renewable energy sources. The only question in my mind is who will own the power. I, for one, am not willing to rent sunshine from a utility. I'd rather grow my electricity at home. Richard Perez

Renewable Energy Curriculum for Native American Community Colleges

The Energy and Resources Group (ERG) at UC Berkeley is in the process of collaborating with native american community colleges on the development of a renewable energy and energy efficiency curriculum. At this early stage, the outlook is very promising—out of 29 tribal colleges in the US, instructors at 20 of them have expressed interest in learning about and teaching this topic.

The curriculum is meant to be a combination of classroom and hands-on learning. It will include modules on the following subjects:

I. Energy Science: energy and energy transfer, energy units, stocks, and flows;

II. Renewable Energy: A. solar energy (sunlight, passive solar, active solar thermal, PV), B. wind energy (electric generators, physics of wind power), C. hydropower (physics of hydro, history, environmental impact, politics), D. biomass (low tech, high tech, photosynthesis, sustainable yield), E. energy storage (batteries, pumped hydro, other technologies);

III. Energy efficiency (building energy efficiency, efficient lighting, appliances);

IV. Environmental / Social Effects: A. fossil fuels, B. nuclear, C. renewable energy;

V. Energy Economics: A. commercial energy market, B. off-grid and small scale;

VI. Social and Cultural Dimensions: A. role of energy in community and society, B. history.

If anyone knows of existing curriculum materials in any of these areas appropriate to the community college level, or has ideas about useful exercises or hands-on activities on renewables and efficiency, please let us know! We'll credit your contributions in the materials we produce.

The tribal college curriculum project is a component of the Native American Renewable Energy Education Project (NAREEP), an education and outreach program of the Energy and Resources Group.

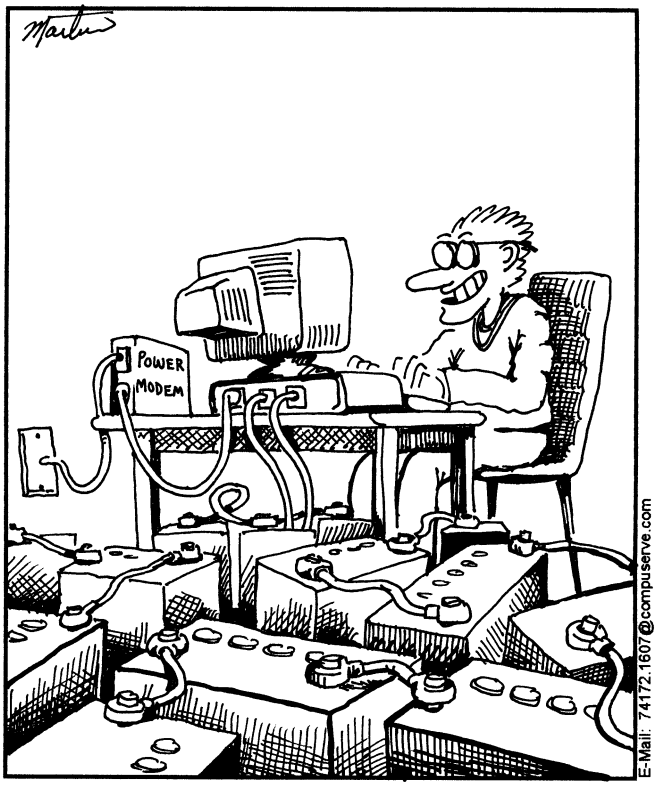
Chris Greacen, Energy and REsources Group, 310 Barrows Hall, U.C. Berkeley, Berkeley, CA 94720 • 510-526-1760 E-mail: cgreacen@garnet.berkeley.edu

Dear Editor:
Top of the day to you and peace! Please accept my humblest apologies for intruding upon your very busy day. At the request of the Director of Ker Xaaleyi: The House of Children, a school in a small, rural village of Bargny-Minam, Senegal, West Africa, I am researching solar desalination processes. This research will also benefit me personally as I am using this topic as my research thesis for an organizational Management B.S. degree at Oakwood College.

Your and your readers' assistance would be greatly appreciated with your comments, resources, and other pertinent information.

Sincerely, Fowzihhah Ali, c/o Home Power Magazine, PO Box 520, Ashland, OR 97520

Hi there, and good luck with your search. There is an article in this issue on water pasteurization (page 44) of this issue. Desalination is a tougher job usually accomplished by distillation. How about it readers, let's do this woman a favor. For our part, we are sending you all our past issues with articles on solar cooking and distillation. An excellent source for solar distillation is



Tapping into the Power of the Internet, Dave was able to download enough energy to recharge all of his batteries

Horace McCracken of Sunwater Solar, PO Box 968, Pima, AZ 85543 • 520-485-0023.

Gas Fridge Answer
Dear people at HP, I do not have an address for the "Woman in Distress" (Letters, HP #51) so could you please forward this info on gas refrigeration to Susan Pettijohn?

I obtained a small booklet on gas refers for $5 from Kerns Gas Refrigeration, 3929 La Mesa Ave, Central Valley, CA 96019 several years ago. Maybe they are still around and/or maybe they have info on the Dometic. The booklet deals with the Servel type units mainly, but covers the absorption cycle system quite well.

To Susan; concerning you particular Dometic. You stated the system "gurgled" when you tried to run it on electricity. This would indicate the fluid is still enclosed. But! The fluid is not distributed around the cycle inside. To do this, rotate/roll the unit 1/4 turn and listen for fluid to flow. Maybe 3-5 minutes is all that is needed (not 24 hours!) keep rotating at 1/4 turn intervals and listening until it is upright again. If the fluid has been heard running thru the pipes the unit will probably begin cooling when started up. If not, or if the fluid has not been heard, repeat the roll process, but in the opposite direction. More likely than not the fluid will be somewhat distributed throughout the cycle and will settle down to operate normally. Usually the fluid is either all out, or it's all in and settled to the bottom, and behaving like a water pump that just needs a little priming.

And just like a first time primed pump it will “cough and sputter”, but work, until it settles down to the normal operating condition.

There are some problems running on gas, by the way. Mainly the flame is very critical. If it burns with even a little bit of yellow tip it is a carbonizing flame and will eventually soot up the chimney, degrading its efficiency to the point of not freezing or even cooling. Clean the soot out of the chimney taking care not to let soot enter the burner top. Careful adjustment of the flame will lengthen the between time for cleaning the chimney.

If it is more convenient to run on electricity, that will solve the soot problem. If it is to be run “off-grid” the electricity situation needs to be considered. If it is to be on natural or LP gas, become absolutely familiar with the inherent dangers of gas. Hope I’ve helped! Sincerely, Richard Cameron, Dillard, OR

Gas Fridge Warning

Dear Michael Welch, I read your reply to Susan Pettijohn’s letter to Home Power. I had an old Servel that stopped working. I did the same thing that you suggested, turning it on its top for 24 hours. I turned the fridge up-right and turned it back on at about 6:00 pm. At about 11:00 pm I checked the fridge and it still had not begun to cool. About 3:00 am my wife Deb got up and checked the fridge. It still was not cooling. She thought that if she turned up the thermostat that it would start cooling. WRONG!

At 3:15 am my fridge went ballistic and exploded in the kitchen. Ammonium gas quickly filled the house. Luckily we had a second floor outside porch. It’s funny but when you wake up your nose does not work right. I thought I smelled propane instead of the ammonium gas. Thinking that the house was filling with propane and about to explode itself, we decided to try and save our house. Deb jumped down and turned the propane off at the tank. i went back into the house and opened the doors and windows to let in fresh air. I ran through the house like a madman opening everything, while Deb came around to the front of the house. After about a minute in the house my lungs were starting to burn and I realized that I was smelling ammonium, not propane. I quickly got out of the house.

Thirty minutes later, and the house still standing, we took stock of our situation. We were both standing half naked wearing nothing but t-shirts. It was about 26 degrees outside. We went into the house and started to clean up the mess.

Apparently the fridge had developed a blockage and when Deb turned up the thermostat, the coil super-heated and exploded. Black soot and dense black liquid spewed everywhere. It was a terrible mess that took days to clean up. We left the house open for the rest of the night and curled up in sleeping bags.

In the morning we had a chance to see the damage. The fridge was totalled. The kitchen was a soot filled mess. I went to a doctor who said I burned my lungs and put me on anti-biotics to prevent infection.

The moral of this story is if something goes wrong with a gas refrigerator, get a professional to look at it. Most RV centers still sell gas/ac/DC fridges and probably know a repairman or company that can service them. I found a repairman that way. I still have a small Dometic gas fridge, but would like to eventually get a Sun Frost as my finances permit. Used gas fridges are still economical if you find one. new ones are expensive, but still cheaper than the Sun Frost.

Make sure that you always service the gas fridge. Clean the chimney and blow out the combustion chamber where lint likes to accumulate. Take it from me, gas refrigerators can be very dangerous! Treat them as such. This is somewhat of an embarrassing tale for my wife and I to tell, but I hope it will keep others from making the same mistake. Alan and Debbie Donnels, Palmer, TN,

DOE News Release

The Department of Energy’s (DOEs) photovoltaic (PV) industry research partners United Solar Systems Corporation and Siemens Solar Industries (SSI), announced major expansions in their PV manufacturing facilities. PV products for a wide range of industrial and consumer applications from battery charging, top grid interconnected power systems, to solar shingles for homes will be produced at the facilities.

United Solar Systems Corp. in Troy, MI, unveiled their new 5MW state-of-the-art thin film production line and announced that their technology has achieved a new world record in stabilized energy conversion cell efficiency. The new $10 million facility incorporates breakthroughs that led to achieving the record efficiencies along with installed innovations in solar cell manufacturing technology that will quadruple production. These innovations were developed in partnership with DOEs Thin Film Partnership and Manufacturing Technology research programs.

Christine Ervin, DOEs Assistant Secretary for Energy Efficiency and Renewable Energy, who participated in the ribbon-cutting ceremony said, “These manufacturing expansions show there’s money to be made in solar technology for those far-sighted enough to make the investment. Renewable energy will supply 50 percent of the world’s power by the year 2050, thanks to companies that recognize the demand for energy choices for the future. It is particularly gratifying to see the results of DOE-sponsored research incorporated into two major commercial PV facilities in the same day.”

United Solar’s new production facility, a joint venture between Energy Conservation Devices (ECD) and Canon Inc., of Japan, utilizes a unique solar cell production technology using one-half mile ling substrates—a process similar to that used in manufacturing photographic film.

The expanded plant also will produce other innovative PV products, including a new line of flexible solar shingles, that were developed in partnership with DOE. The shingles are expected to transform conventional roofing into a residential and commercial power source.

"Thin film technology has been well recognized by experts for its low cost potential," said Stanford R. Ovshinsky, President of ECD, and inventor of ECDs PV technology. "The new world record efficiencies and the advanced manufacturing processes developed by ECD/United Solar makes us uniquely poised for addressing the expanding world PV market."

In another activity, Siemens Solar cut the ribbon on a $3 million expansion at its PV crystal growing facility in Vancouver, Washington. The Vancouver plant supplies PV crystal to SSIs Camarillo, California, manufacturing facility which processes the crystal into PV devices such as emergency highway telephones, traffic signs and navigational buoys. SSI is the largest single supplier of photovoltaic modules in the world, accounting for over 20 percent of total industry shipments. Over 70 percent of SSIs products are exported.

Chet Farris, Chief Operating Officer of SSI, said "This manufacturing is an example of Siemens' commitment of improving solar cell yields and increasing its manufacturing efficiency. It will allow Siemens Solar to ensure that crystal growing, which produces the base material for solar cells, continues to be refined using the state-of-the-art equipment at the expanded facility." US Department of Energy, Washington, DC

More Upscale Systems
Why don't you include more articles on solar installations in more upscale cabins and homes instead of the usual low budget type of home? Here in the southern Nevada mountains we get lots of sunshine and wind. PV and wind are great resources. So, why don't you share more info about the systems designed for a 2,000 to 3,500 square foot cabin/homes.

You've got a great magazine! Keep up the good work. P.S. It's time to do a new article for a buying guide to inverters. Thanks, Brad and Paula of Cold Creek, Nevada

Hi Brand and Paula, We basically publish what our readers send us. See the next letter and its answer. You are right about a buyer's guide article on inverters. The last time I did this was in HP#36 (Aug/Sep 93) and there have been many changes since then. I'll see about redoing this info and making it current. Richard Perez

More Downscale Systems
Let me express my pleasure in your magazine and the wonderful ideas/ideals it generates. It is very comforting to know there are so many people out there working in the direction humanity obviously needs to go.

I would like to see more articles about houses that are smaller in size as it seems to me that many of the ones you detail are quite large. Energy efficiency and production are just one part of sustainability along with the resources it takes to build in the first place and maintain thereafter.

I try (not always successfully but it's a start) to weigh the things I do in the perspective of "what if the other 5.7 billion persons on Earth did this…" Some things like solar ovens or the composting of paper trash would be clear benefits. But what if everyone wanted a 2000 sq. ft. house, even if it was energy independent?

Thanks for all your good work and I look forward to future issues. Nancy Lloyd, Durango, Colorado

Thanks for the kudos, Brad, Paula, and Nancy. More upscale systems? More downscale systems? It is often hard to create a balance between the varying needs of our readers. Everyone has their own thing. We are limited to some degree by the articles that get submitted to us, but within that limitation we try to have something for everyone. There's no way we can be everything for everybody.

But, this is where you and our other readers come in. We don't write most of the magazine. We rely on what you send us. We strongly urge all our readers that have information and systems articles worth sharing to write them and send them in to us, complete with graphics ideas and lots of quality photos! "Hands-On" means your hands, not just ours. The Crew

Polynesian Home Power
Dear friends, Best wishes to you and all readers. Congratulations on *Home Power!*

We look forward to using *Home Power* in Polynesia! Our tropical, volcanic islands have lots of hot sun, humidity, and ocean with hurricanes. We welcome any guidance or suggestion on the best ways and equipment to use here! If you do have any comment or input, please come or do write to me.

While the unaffordable acquisition of finite diesel fuel just increases foreign debt and causes the many poor to become poorer, *Home Power* helps us to use Creation as intended, in this special time of transition of Humankind to global society as it rapidly advances towards the unavoidable world peace!

I am trying to spread *Home Power* throughout the islands between New Zealand, Easter Island and Hawaii. We'll need all kinds of renewable energy equipment for all kinds of energy resources.

Our volcanos are asleep, but were very active less than a century ago. Who can share the ways to use the earth's heat? Geothermal power as well as tidal power could be also well used here.

Western Samoa is the place from where all of Polynesia was settled some 2000 years ago . Polynesia is an area

quite larger than the U.S.A. American Samoa is part of the U.S.A. and just 'next door.'

The equipment we use must be possibly hurricane / cyclone resistant and also be unsensitive to the yearly earthquakes we have. Does anybody have a list of the best equipment that copes with these and our hot tropical conditions?

There was a solar energy company called American Solar King. Do you know it? where is it and at which address? Who's the person to contact? What does it offer? I heard it had difficulties: how did it survive?

Thank you for whatever information anybody can give me. Looking forward to receiving *Home Power* regularly, yours are the renewed wishes for 1996! Sincerely yours, Marco Kappenberger, PO Box 1438, Apia, Western Samoa

Hello Marco, Solar King went out of business in the 1980s. Contact AAA Solar, 2021 Zearing N.W., Albuquerque, NM 87104 • 505-243-3212 for solar thermal equipment. Mick Sagrillo of Lake MI Wind & Sun has done wind systems in your neighborhood (see this issues ad index for access). If you are interested in storm resistant RE, then consider photovoltaics. If PVs are properly speced for the hot climate and securely mounted, they are supremely reliable. If you are interested in hot weather PV performance, then see our hot weather test article in HP#49. Richard Perez

Electric Motorcycle Inspiration

Dear Mr. Perez, I think your magazine is awesome. I've been looking for a good jolt of inspiration for an electric motorcycle project I've been thinking of. I saw your magazine at the bookstore and just got a big boost from the articles, advertisements, and especially the section GoPower. I really want to learn about your story of how you and your friends got off-the-grid. I'm a young man who is looking for ways to make a life as close to nature as I can, considering my being raised dependent on the typical grid and fossil fuel systems prevalent in U.S. society. I have an electrical engineering background from Cal Poly Pomona which now has an awesome solar-powered car which they raced at Sunrayce 95 (I read the article, issue #50, and it pumped me up!). I am thinking of going back to Cal Poly to learn about solar and also applying for the Center for Regenerative Studies, there also, to learn systems of sustaining humans without resource depletion or permanent environmental damage. I want to learn Earth friendly systems or ways of living so that I may enjoy life doing good things for our home planet.

I found your magazine looking for ways to build my dream of an electric motorcycle and *Home Power* helped fuel my fire to expand my dream to include a whole way of life living lighter on the earth with solar, wind, and other RE technologies for my energy needs.

Please plug me into some good resources for introducing myself to EVs, solar technology, and alternate fuel vehicle technology. I also want to meet and talk with people who are living off-the-grid so that I can be inspired to do something similar. Thank you for any help you can give me. Sincerely, Rod F. Garcia, 1917 Longhill Dr. Monterey Park, CA 91754

Hello Rod, Michael Hackleman's book, The New Electric Vehicles will be in print by the time you read this. It would be a good place to start. We're printing your address here so that our readers can contact you. Welcome aboard! Richard Perez

Educate the Politicians

Dear Richard, the Iowa Renewable Energy Association is coming up on 5 years of age. As a non-profit organization (in the true sense of the word!) we are trying to educate our elected politicians in Iowa on what is REALLY happening in the Alternate Energy field. IRENEW is lucky to be a member of a SEED campaign organized by the Union of Concerned Scientists from Washington, DC, and Heather Rhoads of Iowa Citizens Action Network. In my mind there is no other way to even begin to have a voice to be heard. Our SEED has over 50,000 members in Iowa and still growing.

Other important points that may help organizations in other states in promoting renewables:

Politicians have to have facts to make even an educated guess so they need our input. The only facts, regrettably, that most know have been from vested interests, i.e. utilities. Investor owned utilities (IOU) in Iowa have lived with subsidies for so long that they can't see the true cost of what they are producing. Unfortunately this is the information they pass on to legislators. In my mind one real nasty fact that can't (shouldn't) be ignored by politicians is that electricity produced by nuclear power here in Iowa cost 25 cents kWh to produce and the utilities claim they can produce it for 6 cents and even buy it on the open market for 1.5 cents! Of course, subsidies have nothing to do with this difference! George Orwell couldn't have written a better script. Up is down, good is bad, I get subsidy, you get …!

If the politicians still seem unsure, then hit them with job loss and unemployment. In Iowa, a year ago there were seven IOUs. A few months ago it was at four, and last month the latest merger will make it two and there will be jobs lost. The IOUs admit there will be downsizing. This will make them "leaner and meaner" and more competitive. One of the bigger obstacles in Iowa is the IBEW Union. The electrical workers are losing their jobs because of mergers and downsizing and think the AEP law in Iowa (ed. note: an Iowa law requiring IOUs to buy 105 MW of power by Alternative Energy means. The law is currently under attack by the utilities and their state public utility board.) is a potential problem. EDUCATE the politicians as to what is happening and will happen with jobs if AEP laws are not enforced.

Finally, if the politicians are still nervous about bucking big business, hit them with ECONOMIC DEVELOPMENT! Jobs are created in the production of the equipment for alternate energy, jobs are created by the installers of the equipment, and, in Iowa for example, the money for energy will be kept in state, not exported. One argument by the IOUs in Iowa is that the money spent for out of state coal doesn't count because the coal is burned and used in state!

Richard, I hope these few ideas are helpful and offer some insight into the not-so-insightful life of politicians on alternate energy. Thanks, Tom Snyder, President of IRENEW

Hi Tom, I want to congratulate you on the good work, It's grass roots organizations like yours that make changes really happen. I salute you! Richard Perez

More Low Tech
Love your publication from the Light Bulb Mandala on Issue One (free) to the high gloss it is today. We all necessarily transform for the better. I consider the price a good (great) investment on my Continuing Alternative Education. Please start my renewal sub with Issue #50 as #49 was my last.

Love to see more articles on Low Tech, i.e. solar fruit dryers, solar vents, water wheel air compressors, also small scale biomass. You have my respect, admiration, and now, my money. Love, Chaz Tozycki, Anahola, Kauai, HI

Aw shucks Chaz, thanks for the flowers and the subscription. Our mission with Home Power is to spread the word about renewable energy. Our newer slick appearance places Home Power on newsstands worldwide. Richard Perez

Burning Desires
As I burn yet another brush pile, columns of smoke and sparks charging into the air above, I can't help but ponder some kind of alternative to this endless cycle of slash burning. Chippers are not only expensive, but also noisy, fuel consuming, temperamental, and limited (hard to chip a root wad or larger diameters). I think of the heat and energy that is essentially wasted but I can come up with no viable solution. How about a *Home Power* competition—sort of like the solar cooker design—where ideas for slash burning alternatives are sent in, judged, awarded, etc. I know many people who have agonized over this as I have. How about the … "Burning Desires" competition [the overwhelming want of slash-burning alternatives.] Barbara Lepak

What a challenge, Barbara! How about it readers, are there alternatives? I know that I would love to do something useful with all the energy we waste in burning wood leftovers. Richard

Evaporative Cooler Conversions
Love all the technical info. I look forward to every new issue. A year ago I started with 40 acres of virgin land north of Tonopah, Arizona, 4 miles off-grid. And now I'm pumping 100% of my water from a 630 foot well with RE, 100% of my electricity from Oct. thru June, and 75% - 80% during evaporative cooling season. Would like to see more articles on appliance and evaporative cooler conversions from AC to DC motors. Richard J. Halliburton, Tonopah, AZ

Hi Richard. Check out the article on Cool Towers in HP#41. The cool tower is very efficient and suited to your environment. We use a commercial room-sized, swamp cooler in our office at Agate Flat. I have not gotten around to replacing its motor with something more efficient (it now uses about 350 watts) because we only use it rarely. It really works! It drops the temperature in the office by a good 12 to 15 degrees and ups the humidity to about 40% from about 15% outside. While we humans here don't really mind the heat that much, our computers refuse to run if the temperature is above about 90 degrees. The increased humidity also reduces static electric problems in the office. If you live in a low humidity environment then evaporative cooling is the way to go. Richard Perez

Dad's 50's EV
I like print size, large pages, style, and readability. Found Issue #50 at the bookstore. I like the access info at the end. All articles I see in all magazines concerning the Sunrayce give about zero on tech, schematics, motor design and drive pix.

In the late 50's and early 60's, my dad built an EV from two old bikes with a platform between. He used 12v car batts, aircraft (WWII) starter, lawn mower motor / Gen combo, and carbon rod controller. The ridicule he suffered for his dreams (we were dirt poor) was unbelievable. He was even trying regenerative braking. Dad is 82 now, and still dreams about EV. Robert Payne, Coldwater, MS

Nerds Revolt
Dear Mr. Perez, On page 102 of Home Power #50, in a reply to a letter, you said, "I totally agree about Western Science's apolitical attitude—nerds are responsible for their creations. To demand anything less is to demean us all." Your use of the term nerds to refer to scientists and engineers is demeaning to all of the people in those two professions including the ones who develop technology for renewable energy. This type of slur is not helpful and will only turn off from your magazine the engineers and scientists like myself who are not apolitical and are for responsible technology. Thank you, Charles E. Oliver, Jr.

I apologize for this unintended slur, Charles. Around here, the appelation "Nerd" is considered a badge of honor won at great effort. I'm sorry I've offended you. Richard Perez

HP=High Value
Relax, people, this is worth more than six cents a day! Mark Walsh, Guerneville, CA

Thanks Mark. I never really thought about HP costing 6¢ a day, but you're right. We try hard to make Home Power effective, useful, and as inexpensive as possible. It's an up when our readers notice. Richard Perez

Every Month?
Thank you for producing such an excellent publication. My off-grid quality of life would be much different if it were not for your product features. Why not publish an issue per month? All of us readers could benefit from additional technical information provided in Things that Work! and Code Corner. Keep up the good work. John Oertel, Los Alamos, NM

In the immortal words of Bill the Cat, "Aaaaaacckk." What are you trying to do, drive the HP crew to an early grave? Every other month is tough enough. We actually published HP1, HP2 and HP3 only a month apart. It was frantic and the mag was a lot simpler in those days. I figure we would have to at least the triple the size of the Crew in order to go monthly. Good nerds are hard to find and deserve at least a living wage. This means increasing the price of the mag. All in all we'd rather stay bimonthly. Richard Perez

Opportunity Knocks
I only recently discovered *HP* from my brother-in-law, a marine engineer. I have a limited knowledge of anything electrical; alternative power sources have fascinated me for a long time and I would like the "mystery" of it all to turn to understanding—and eventual application. I've been in construction all my life (55 years old).

The past nine years I've been involved running a commercial establishment in Big Sur, CA, in an area that is remote enough to be 30 miles from the nearest utility. We use a Cummins 220 at 1200 rpm to produce 60 kw. The gen-set is noisy and smelly and I was interrupted in my efforts to extract heat from this power plant because in August, the entire business burned to the ground. I lost my general store, cafe, bar, gift shop, and retail store spaces. My property is zoned for 30 motel units. Now I must rebuild everything. It is a good time to consider using renewable energy. I think you can help. This could be a large opportunity for someone. I'm open to suggestions. Looking forward, Harry Harris, #1 Pacific Valley Center, Big Sur, CA, 93920

Hi Harry. Sorry to hear of your misfortune. Every cloud has a silver lining, and this may be the opportunity you envision. How about it, readers, should he go for it? And how about it, all you HP reading installer/dealers, would you like to help him with this project? The Crew

Washington State Intertie
Encouraged by *HP*, we have worked out a buy-back agreement with our local utility for a property in the San Juan Islands. If the permit gods are willing, we will have an intertie system operational within the next few months. Your magazine has been instrumental in getting us going instead of just talking about RE. Thanks—and keep up the good work Mike Williamson, Seattle, WA

Aw Reet Mike! I can think of no more worthwhile undertaking that selling RE back to the utilities. It strikes a blow for the environment and for personal freedom. Let us know how it turns out. Richard Perez

Harness the Indian Sun
I said, "I'm going to India to harness the Thar desert a bit." My friend said, "Then you need *HP*" (Starting with #40.) I would have done everything wrong without you great people. Thank you. G. McKee, Shanti Progress Int., Jaipur, Rajasthan, India

We're pleased to have been of help! The Crew

More Product Reviews
I've been getting Home Power since Issue #1, I'm grateful for all I've learned from you. I feel recent issues have gotten away from usable, nitty-gritty information that helps me improve my system and learn about new products that will have a real effect on how my system functions.

I understand your wanting to only review Things that Work!, but there are not many TtW! product evaluations that appear. Does that mean most products don't work? Unless you give us a "Thumbs Up" review, we don't know whether you just haven't evaluated a product or it flunked the test. I'd like to see a lot more product views. For example, there are now many different metering options for keeping track of batteries—are any of them good? You have a very important role in my life, I hope you'll come through. Kal Winer, Union, ME

Hello, Kal. Wouldn't it be nice if we could test every product out there, every time it was re-introduced or upgraded. Too little time, too few test beds.

Often we will test products and find significant room for improvement. We don't give a thumbs up, but that doesn't mean the product is bad. Often manufacturers will take the product back to the drawing boards and make it even better. It is much more productive than publicly condemning a slightly-off product. We believe in this method as we have seen it work successfully. The manufacturer has come back with a now superior product. So, our role is not only to make sure that RE product consumers get a product that lives up to its advertised capabilities, but it is also to make sure that you have access to excellent working equipment. By this strategy, we help deliver equipment that keeps getting better and better.

In terms of system instruments, we have tested and given the Thumbs Up! to the TriMetric, the Link 2000, the Cruising Equip. Amp-hour series and, in this issue, the new E-Meter. All of these products work as advertised. Richard Perez

Q&A

Genny Tests
Richard Perez: Your article in Issue #51 regarding generators was a good introduction to the problems encountered in using these "beasts" to keep "the grid" away. I would like to see more in depth articles about the best way for all of us to deal with this necessary evil. Perhaps *Home Power* could do that kind of research on specific equipment and methods that you do on on RE products.

I am using a hybrid system of PV and hydro, but our cold winter temperatures makes operation of the hydro risky business for two or three months a year. My question has to do with the idea of using an alternator similar to the one on my hydro unit and powering it with a small gasoline engine. have you tried this, does it work, is it better at filling the batteries, are there products of this design?

P.S. Thanks for the explanation of the two phase nature of the gasoline generator, along with the idea to use both legs of the 110 v circuit. That had been a real mystery for me for some time. Chuck Carleton, Mosca, CO

Hi Chuck, I'm glad you found the engine/generator article useful. I'd love to test all the various generators for electrical purity, load ability, and fuel consumption. Unfortunately our small crew can barely keep up with testing PVs—if we only had more time, more people, and more money….

I wrote an article in HP #42, pages 28–32 about mating an automotive alternator to a small (5 hp) gasoline engine. This is a simple homebrew project that can produce around 100 Amperes of DC current for a 12 Volt battery system. This setup is very efficient and consumes only about one quart of gasoline per hour. We put over 13,000 hours on the unit I built before we outgrew it and went to a larger 120 vac generator setup. Richard Perez

Batteries for Wind
My family uses 15 kwh average per day. When we build our new home all of the electrics will be of the most efficient designs. We will be off-the-grid (1/2 mile away). I plan to use a combo of a 10 kw Jacobs and solar. My difficulties have been in figuring out the necessary battery bank size to store 15 kwh. How does this compare to amp-hrs? Could you publish a simple formula conversion sheet to help us readers convert from one point to another.Thank you, Chris Schaefer, Bristol, NY

Hi, Chris. The conversion between kiloWatt-hours (kwh) and Ampere-hours (Ah) is really simple, just divide the kwh by the battery's voltage. Let's look at your system. Since you are using a fair amount of power, I'd spec a 24 Volt battery system. Take your consumption (15 kwh) and divide it by the battery's voltage (24 VDC) and you get a consumption of 625 Ampere-hours per day. The math is simple, but actually determining the size of your battery is far more devious. Battery performance and effective capacity varies with the technology used (lead-acid or alkaline), the temperature at which the battery operates, how long you wish the battery to last (the more frequently you empty it and refill it, the shorter its lifetime), and finally what kind of wind and solar resources do you have to recharge the battery. Whew! it's a lot of stuff to account for. By a very generic rule of thumb, consider four days to be the minimum amount of storage your system requires, so multiply your daily Ampere-hour consumption by four and you'll get 2500 Amp-hours at 24 Volts DC. If your system is primarily wind sourced and your wind is variable, then consider seven days of storage in the battery. If you have a fair number of PV modules and a decent solar resource, then four days may be adequate. A battery of this size will be expensive, at least several thousand dollars. I'd advise getting some system design help from a local professional who knows the RE resources in your neighborhood. Richard Perez

Multi-Spectrum Solar
What frequency of the solar spectrum does a photovoltaic actually use? I know that it will be slightly different for each manufacturer. What is the best operational temperature for photovoltaic? Manufacturer specification versus actual site environment.

The reason for my question: I believe it is possible to direct part of the spectrum to the photovoltaic and the other part of the spectrum to other devices, such as a solar water heater. This would be more efficient use of the sun's energy, specially in smaller confined areas. Michael Sendelbach, Pearland, TX

Hi Michael, you ask some very interesting and astute questions. I sniff you have a Physics background. OK, here goes. PVs use the visible and near ultraviolet portions of light's spectrum. Infrared merely heats up the PV and reduces its power output. PVs are rated at a cell temperature of 25°C. Every manufacturer will also provide ratings for temperatures at 50°C. After over six years of real world PV testing, I can testify to the accuracy of the PV manufacturers' ratings. These fellows are not just blowing smoke. The PV modules work just like they say they will.

Over the years there have been many schemes to produce both PV electricity and hot water from a single (usually employing some concentration scheme) device. I even designed a combo PV/DHW module for a company back in 1987. The design looked great on paper, but we never got it to stop leaking…. It just hasn't worked out for anyone in the marketplace. The hybrid modules were difficult to install and maintain. I cannot imagine a roof without enough space for both discrete PV and hot water panels. At about one kiloWatt per square meter, there is more than enough sunshine to go around. Richard Perez

Wood Burners

I am writing to you for some help. I will need to build a wood burning stove for remote living and will need some technical guidance. Do you know of some company, individual, etc. which could provide details on the most efficient wood burners, why they are efficient, and diagrams to build one? This may be asking too much, but I thought you would know of a lead. Thank you for your help, Dennis R. Burr, Lumby, BC, Canada

Well, Dennis there is only one person in the whole world that I know can help you out. Contact Bill Battagin at Feather River Stove Works, 5575 Genessee Road, Taylorsville, CA 95983 • 916-284-7849. Bill builds the most efficient woodburners I have ever seen—and he does it using solar electricity for all his welding! We have used one of his wood heating stoves for the last three years. It uses catalytic secondary combustion (minimal pollution, yea!) and has cut our wood consumption to less than 25% of our old wood heater. If you're interested, we profiled Bill and his system in HP #33. Bill is a genuine Solar Bozo and happy to share his hard won knowledge with anyone who will seriously listen. Richard Perez

Idle Systems

What do you do when you are gone for two weeks or two months, etc. with PV systems? Are there controls to handle this situation? You have addressed these somewhat in a letter to you. Seems an article would be great. What about batteries outside in winter? Chargers, etc. outside in winter? Jerome J. Morrow, Montrose, CO

Hi Jerome. Well, when we leave HP Central for a week or more, I simply go to the circuit breakers between the different PV arrays (we have five) and the battery. I open the breakers on four of the arrays and leave them open until we return home. We also use a PV regulator (Heliotrope CC120) and it regulates the voltage at a point that will not damage the batteries even if I didn't switch off some of the arrays. I switch off the surplus arrays because experience has shown me that if I don't I will be looking at major battery watering upon returning home. Switching off some of the PVs is easier than resetting the regulator down in voltage, and far easier than watering the 150 cells in our main battery. Most batteries, especially lead-acid batteries, will work far better if kept warm. If you are using batteries in cold climates, then give them a snug, warm home. Electronics will operate at freezing or below, but they are really designed to work best at room temperature. Bottom line is keep your gear warm. Richard Perez

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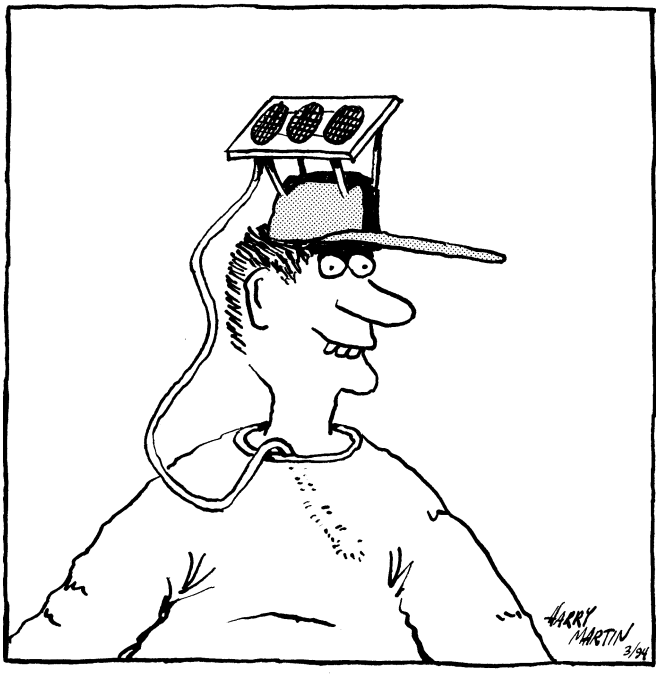

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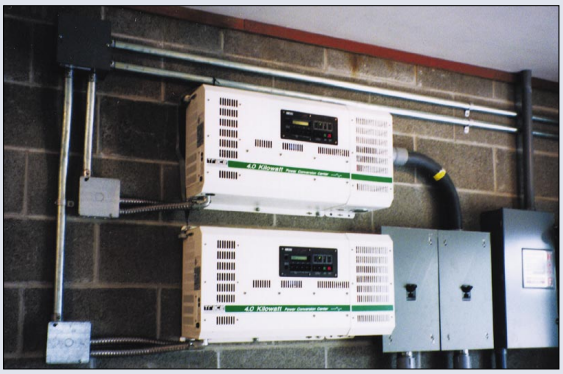

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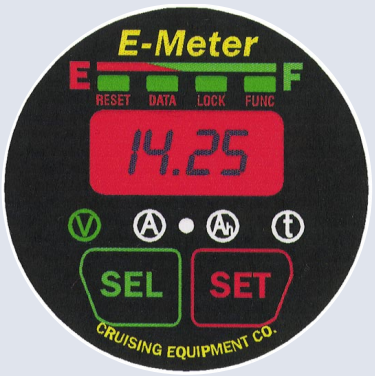

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